Parental communication and infant language development: the influence of premature birth and socioeconomic risk

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I. Abstract

Preterm birth is birth occurring before 37 weeks gestation. Preterm birth is associated with an increased risk of impairment in many neurodevelopmental outcomes, including a higher risk of later language impairment and delay. Socioeconomic deprivation is also a known risk factor for later language difficulties. Moreover, mothers from a low socioeconomic background are at an increased likelihood of having a preterm birth. Socioeconomic deprivation is linked to a decreased rate of language exposure in early childhood, but it is unknown how prematurity influences this relationship. Longitudinal studies examining infant language output are required to untangle the contributions of both socioeconomic status and prematurity to poor language outcomes.

The aims of this thesis were to investigate the relationships between gestational age at birth, socioeconomic deprivation, and language exposure, operationalised as parental gesture type and frequency during play in infancy. The creation of a novel coding scheme allowed for the capturing of parental language and gesture. I hypothesized that there would not be differences in the use of vocabulary and gesture of parents of preterm vs. term infants. I predicted that parents from a lower socioeconomic status would use less vocabulary and gesture when communicating with their infants. Finally, I explored relations between familial factors such as socioeconomic status, gestational age at birth, and parental communication at 9 months as predictors of infant language outcomes at 24 months.

47 parent-preterm infant dyads, mean gestational age of 29 weeks (range of 24-31 weeks), and 53 parent-term infant dyads, mean gestational age of 39 weeks (range of 36-42 weeks), from the Theirworld Edinburgh Birth Cohort were studied (www.tebc.ed.ac.uk). Parent-infant dyads were assessed at 9 months corrected (range of 8-10 months) for the preterm group and 9 months (range of 8-11 months) for the controls. 58 male infants and 42 female infants were included in analyses.

Parents were video recorded for 10 minutes interacting with their child during play. Videos were coded for parental language and gesture using the novel coding scheme created during the course of this project. The Scottish Index of Multiple Deprivation 2016 (SIMD2016) rank was used to describe deprivation.
Between group comparisons of parental gesture frequency were made using Student's t-test, and the relationship between parental gesture and SIMD was evaluated using Pearson correlation. Multiple linear regression was used to investigate if parental language and gesture, prematurity, or family socioeconomic status had an effect on infant language outcomes at 24 months (measured using the MacArthur Bates CDI at 24 months corrected and the communication scores from the Vineland Adaptive Behaviour Scales).

Findings from the parent child play showed no significant differences in the language and gesture used by parents of preterm infants vs. term infants during interaction. Socioeconomic status was associated with parental communication, and revealed that higher SIMD scores were positively correlated with word types, word tokens, and mean length of utterance. In other words, parents from a higher socioeconomic background spoke in longer sentences, with more words and with a more varied vocabulary. Examining relations over time, we found that parental communication at 9 months was not significantly related to language or communication at 24 months, while controlling for SES and gestational age. Due to a drop in sample size from 9 months (n=100) to 24 months (n=43), the robustness of this final analysis is limited.

In conclusion, this thesis has shown that socioeconomic deprivation has an effect on how parents communicate with their children during play in late infancy, and that this relationship is not directly influenced by gestational age at birth. The observation of socioeconomically related effects on parental language suggests that deprivation, and the increased rate of deprivation amongst the preterm population, may be a vital factor to consider when examining the increased risk of language delay within the preterm population. Further work, examining a larger sample of

later infant language, is needed to increase our understanding of potentially important early predictors of language including gestational age, socioeconomic status, and parental language and gesture.

II. Lay Summary

About 1 in 10 babies around the world are born too early. Being born early, also called being born preterm, is associated with difficulties with language development. We also know that babies who come from deprived backgrounds are more at risk for language difficulties. Finally, we know that mothers from a more deprived background are more likely to have a preterm birth than mothers from a less deprived background. Some research shows that babies from more deprived backgrounds are exposed to less language growing up, but we don't know if preterm babies also experience this. This is important because how parents use language and gesture around and with their babies plays an important role in how babies learn to communicate.

The first aim of this thesis was to compare how parents of preterm and term babies use language and gesture when they're playing. By doing this, we can see if preterm babies are being exposed to more or less language and gesture than babies born at term. The second aim was to compare how parents from less and more deprived backgrounds use language and gesture with their babies. By looking at how parents are playing with their infants, we can see if parents from a more deprived background are using more or less language and gesture than parents from less deprived backgrounds. The last aim of this thesis was to look at how some of these babies are communicating at 24 months, to see if their language abilities are influenced by being born early, coming from a deprived background, or having a parent that uses a high level of language and gesture.

This thesis found that parents of preterm babies are using language and gesture in the same way as parents of babies born at term. However, it also found that parents experiencing more deprivation use less words and shorter sentences when playing with their infant. This means that infants from a deprived background are being exposed to less language and gesture. Finally, this thesis found that being born preterm, coming from a deprived background, or having a parent that uses high levels of language and gesture did not strongly predict infant language development at 24 months. Although, we only had a small number of infants at 24 months so these results should be interpreted carefully.

This thesis showed that deprivation affects how parents interact with their infants, and that this relationship is not directly influenced by being born preterm. This is important because it indicates that the increased risk of language difficulties seen in preterm babies may be due to the high levels of deprivation often experienced by babies born preterm, rather than being premature itself.

If parents experiencing high levels of deprivation use less language and gesture, then this has important implications for both preterm and term born babies. Future work is needed to better understand how deprivation, prematurity and parent language interact, so that we are better able to predict which babies will be at risk for language delays, and how we can best support them and their families.

III. Declaration

I confirm that the work presented in this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where states otherwise by reference or acknowledgement, the work presented is entirely my own.

Sinéad O'Carroll

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IV. Dedication

I'd like to dedicate this thesis to my late mentor Dr. Margaret-Ann Armour, whose passion for encouraging women in science was only matched by her love of Scotland.

V. Acknowledgements

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VI. Abbreviations

CLAN	Computerised Language Analysis
ELAN	EUDICO Linguistic Annotator
GA	Gestational age
GCP	Good clinical practice
IBQ	Infant behaviour questionnaire
MLU	Mean length of utterance
NNU	Neonatal intensive care unit
SIMD	Scottish index of multiple deprivations
SES	Socioeconomic status
SSQ	Sleep and settle questionnaire
TEBC	Theirworld Edinburgh Birth Cohort

VIII. Outputs

Publications

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2018- Theirworld Edinburgh Birth Cohort Scientific Advisory Meeting

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1 Prematurity and socioeconomic risk

1.1 Outline

In this chapter, I will provide a definition of preterm birth. I will briefly examine some of the known risk factors thought to cause early delivery, and some of the developmental consequences that follow, such as atypical neurological development and cognitive risk. I will discuss the relationship between preterm birth and socioeconomic status. I will then elaborate on the difficulties in accurately capturing socioeconomic status, and the important consequences of high and low socioeconomic status on infant and child development. As the focus of this thesis is on language outcomes, the following chapter will consider the specific outcome domain of language and how it is influenced by preterm birth and socioeconomic risk.

1.2 Causes and consequences of prematurity

Preterm birth is defined as any baby born alive before 37 weeks of pregnancy. Babies born at less than 28 weeks are referred to as extremely preterm, those born between 28 and 32 weeks are referred to as very preterm, and those born between 32 and 37 weeks are considered moderate to late preterms (Blencowe et al., 2013).

1.2.1 Causes

Preterm birth can occur spontaneously, either as spontaneous onset of labour or following a prelabour membrane rupture, or through medical intervention such as caesarean or labour induction (Blencowe et al., 2013; Goldenberg et al., 2008). Although it is not completely understood what directly causes preterm birth, certain maternal, child, and social risk factors have been identified. Multiple gestations are 10 times more likely to result in preterm birth (Blondel et al., 2006). Additionally, maternal history of preterm birth is a known risk factor for preterm delivery, with mothers who have already had a prior preterm delivery at a significantly higher risk of additional preterm deliveries (Plunkett and Muglia, 2008). Infections, including intrauterine infections, have also been linked to preterm birth, though the exact mechanisms through which the relationship operates is less understood (Nadeau et al., 2016).

Maternal lifestyle factors such as high levels of stress, depression, and tobacco use, have all been linked to preterm birth (Goldenberg et al., 2008). Additionally, high and low maternal ages, low educational level and obesity have all been linked to an increased likelihood of preterm birth, though it is not clear the mechanism through which maternal factors are related to preterm birth (Muglia and Katz, 2010). Demographic factors, specifically socioeconomic status (SES) have been significantly linked to preterm birth, with research from the UK suggesting that women experiencing deprivation are nearly twice as likely to be at risk of preterm delivery than those living in less deprived areas (Smith et al., 2007). While the exact way in which socioeconomic status and premature birth are connected is not clearly understood, there is significant evidence that there is an important relationship between the two (Kramer et al., 2000). I will review the relationship between prematurity and socioeconomic status in the latter half of this chapter.

According to the World Health Organisation an estimated 15 million babies are born preterm every year, with additional sources reporting that that trend is steadily increasing (Chawanpaiboon et al., 2019). In the UK, it is estimated that 6-7% of births are preterm (Chawanpaiboon et al., 2019). This observed increase could be due to many factors including improved medical outcomes, increased viability, or increases in maternal age and access to fertility treatments (Blencowe et al., 2013). Regardless of the cause, the increase in preterm birth rates are not without consequence (Smith et al., 2007).

1.2.2 Early life consequences following preterm birth

1.2.2.1 Maternal outcomes following preterm birth

Preterm birth is considered an often traumatic and distressing experience for parents, with mothers in the neonatal intensive care unit more likely to exhibit symptoms of posttraumatic stress and depression compared to mothers who do not have infants in the neonatal intensive care unit (Vanderbilt et al., 2009). In addition, the effect of preterm birth on mothers can have important developmental consequences. Maternal grief post preterm birth has been associated with increased rates of insecure infant-mother attachment (Shah et al., 2011). The maternal outcomes of preterm birth appear varied, with some research finding that the impact of preterm birth on mothers, in terms of continued stress and emotional distress, appears to vary depending on child medical risk status and developmental outcome (Davis et al., 2003; Singer et al., 1999).

1.2.2.2 Infant health and economic consequences

Preterm birth is the second leading cause of child death under 5 years of age (Blencowe et al., 2012; Smith et al., 2007). A recent systematic review found an inverse association between gestational age at birth and economic costs, with decreased gestational age associated with increased costs (Petrou et al., 2019). Additionally, children born very prematurely often require a high level of specialised care post discharge, a trend which has been found to continue into early and later childhood (Larroque et al., 2008). As a result, the economic costs of preterm birth are great, and go beyond the immediate costs incurred by the healthcare system during the delivery or neonatal unit stay. Increased social services costs, special education costs, out of pocket expenses and lost productivity, are all considered part of the direct economic consequences of preterm birth (Bhutta et al., 2002; Petrou et al., 2011).

1.2.2.3 Neurological consequences of preterm birth

In addition to significant economic costs, preterm birth can have a varied and profound impact on normal brain development (Ortinau and Neil, 2015). As brain development is a complex process typified by many connected events, the effect of premature labour on infant brain development is diverse, and often dependent on the maturational stage of neurological development at birth (Ortinau and Neil, 2015). Patterns of cerebral injury in preterm populations are varied, and can lead to a wide array of later neurological, developmental and behavioural difficulties (Rees and Inder, 2005; Volpe, 2019).

1.2.2.4 Motor outcomes following preterm birth

A national cohort of extremely low birthweight infants in Finland found a considerable disability rate at age 5, and half of all extremely low birthweight infants were found to have coordination difficulties (Mikkola et al., 2005). Preterm infants, especially infants of very low birth weight are also at an increased risk of cerebral palsy, a non-progressive motor disorder (Johnson et al., 2009; Vincer et al., 2006). In addition to cerebral palsy, preterm infants face a higher risk of respiratory impairments, including acute morbidities such as chronic lung disease (Glass et al., 2015). That said, sensory impairments, such as severe or moderate visual or hearing impairment, are less prevalent than other neurodevelopmental outcomes in the preterm population (Johnson et al., 2009).

1.2.2.5 Cognitive outcomes following preterm birth

Preterm birth is associated with numerous non-optimal developmental outcomes and is a leading risk factor for cognitive impairment in childhood (Johnson et al., 2015). A meta-analysis found that preterm birth is associated with specific cognitive delays, with low birth weight and gestational age significantly correlated with decreases in cognitive scores (Bhutta et al., 2002). As per previous research, lower birthweight and gestational age were associated with lower cognitive scores. It is important to note that this meta-analysis was not able to account for any influence that demographics, such as socioeconomic status, would have on the cognitive outcomes measured. Nevertheless, there is robust evidence suggesting an increased risk of cognitive delays or difficulties within the preterm population (Twilhaar et al., 2018).

Woodward and colleagues compared 105 preterm children with aged matched peers over a two-year period. They found that across neuromotor, cognitive, language and behavioural domains, children born prematurely were at an increased risk of developmental problems and delays (Woodward et al., 2009). Additionally, gestational age was related to the severity of impairment; with lower gestational age associated with increased problems across multiple developmental domains. These results remained even after controlling for demographic factors such as socioeconomic status, which suggests that prematurity itself is a risk factor for later developmental concerns (Woodward et al., 2009). Children born prematurely have also been found to score lower than their full term peers on executive function tasks, and parental responses indicate that children born early have trouble with mental planning, organisation and memory (Anderson and Doyle, 2004).

In another study, extremely low birthweight infants were found to score lower on tests of cognitive ability, language processing, gross motor, attention, behaviour, adaptive behaviour and academic achievement than infants with a higher birthweight and infants born at term (Hack et al., 1994). As these skills are considered vital for later school success, the authors suggest that the very low birthweight children examined in this research are at a unique and serious disadvantage (Hack et al., 1994).

1.2.3 School age consequences of prematurity

1.2.3.1 Learning and attainment outcomes

At school age, children born prematurely are more likely to have learning difficulties than their term born peers (Litt et al., 2005). Preterm birth is also associated with poorer school performance (Quigley et al., 2012). Very low birthweight infants are more likely to have difficulties with reading, spelling and maths compared with peers who were born at a higher birthweight (Saigal et al., 2000). Moreover, birthweight is significantly associated with an increased risk in measures of cognition and academic achievement (Saigal et al., 2000). Educational difficulties have also been observed in children who were born late preterm, between 32 and

35 weeks, including an increase in requiring extra educational support, and having poor outcomes on many academic domains including writing and maths at 7 years of age (Huddy et al., 2001). Very low birthweight children have been reported as having lower scores on mathematics and reading comprehension compared to matched controls at 12 years of age, suggesting that the developmental consequences of early birth could remain well into childhood and adolescence (Botting et al., 1998). A recent cohort study reported that preterm children displayed reduced cognitive function compared to term born peers from infancy to 19 years. (Linsell et al., 2018). On a sample of middle school aged children born prematurely, at approximately 11 years of age the preterm group had low academic achievement, increased behaviour problems, and increased incidents of ADHD, grade repetition, and speech and language impairment (Taylor et al., 2000a).

1.2.3.2 Neurodevelopmental diagnoses

Preterm children are significantly more likely to have later attention problems and to be diagnosed with ADHD (Taylor et al., 2000b). These attention risks are long term and sometimes severe, with very low birthweight children at an additional risk for never catching up with full term peers (Taylor et al., 2000b). Additionally, preterm infants are at an increased risk for a later positive autism screening, though the precise nature of the association between autism and prematurity is not yet fully understood (Guy et al., 2015). A large study found that preterm children were more likely to have increased hyperactivity and peer problems compared to a control group (Delobel-Ayoub et al., 2009). Additionally, an association between cognitive performance and total behavioural problems was found, with an increase in behavioural problems associated with lower cognitive performance. When adjusting for low cognitive performance and environmental factors, preterm children remained at a significantly higher risk for behavioural problems at 5 years of age. Preterm children also had a higher prevalence of hyperactivity, emotional problems and inattention (Delobel-Ayoub et al., 2009).

1.2.4 Resilience within the preterm population

It is important to note that despite the increased risk of adverse developmental outcomes, many infants born prematurely adjust well into childhood and later development (Saigal et al., 2000). A study of 173 6 year olds born preterm found three patterns of risk and resilience; some children experienced significant difficulties (12%), some remained at risk for developmental issues (57%), and others exhibited resilience across development (31%) (Poehlmann-Tynan et al., 2015). Certain protective factors for preterm infants have been identified. Breastfeeding is thought to be particularly beneficial to preterm infants, with evidence suggesting positive effects of breastfeeding on neurological, visual and cognitive development (Blesa et al., 2019; Lechner and Vohr, 2017). Indeed, randomised control trials also suggest that breastfeeding can improve children's cognitive development (Kramer et al., 2008). Additionally, more supportive home environments, defined as having high levels of parental involvement, access to play materials and a well organised physical environment, are associated with improved cognitive development and decreased emotional dysregulation in very preterm children (Cheong et al., 2020; Landry et al., 2006; Treyvaud et al., 2012). Moreover, the positive effects of supportive parenting and home environments are found to last well into development (Treyvaud et al., 2012) As mentioned previously, low SES mothers are at an increased risk of having a preterm birth, and one factor that can confer resilience is a high SES background. Some research suggests that prematurity itself may not necessarily be the sole risk factor for later developmental impairment, but may in fact be mediated by external socio-demographic factors (Blesa et al., 2019; Ene et al., 2019; Foster-Cohen et al., 2010).

1.3 Socioeconomic status definition and measurement

Socioeconomic status is a complex, multidimensional construct that encompasses measures of economic resources and societal factors (Hackman and Farah, 2009). Socioeconomic status will be referred to as SES for the remainder of this thesis. While SES is recognised as being amorphous, many attempts have been made to quantify it, and consequently the measurement of SES is not without controversy (Braveman et al., 2005). In their review, Braveman and colleagues present a wide-ranging exploration of issues in the measurement of SES (Braveman et al., 2005). The most common markers of SES used in research are income, education and occupation (Braveman et al., 2005). As such, developmental researchers look to the SES of parents and family units when examining the effects of SES on infant and child development. There is a range of ways to measure SES but self-report pulled directly from participants or from census or other government data is most common (Braveman et al., 2005). Income and education achievement is typically measured by self-report or credentials of formal education, while the measurement of occupation relies on occupational categories that can be wide and vary significantly between countries. While income and parental education are often found to be highly correlated, research suggests that they are not interchangeable, and that both capture distinct facets of SES (Braveman et al., 2005). Education specifically has been posited to capture non-economic social advantages, such as increased literacy, enhanced problem solving skills and higher overall health knowledge, that may be consequential when conducting health or developmental research (Braveman et al., 2005).

As SES is measured in a variety of different ways, there is significant controversy surrounding which offers the most accurate representation. Consequently, one of the biggest methodological challenges when reviewing SES focused studies is the inconsistencies in measurement (Braveman et al., 2005). Historically SES has been measured both as a single factor, such as parental income, or through a combination of multiple factors, such as parental income and education (Hoff-Ginsberg and Tardif, 1995). In American research specifically, SES is often confounded with race, and it can be difficult to unpick the effects of both (Hoff-Ginsberg and Tardif, 1995). Given the variability within SES measurement, it is difficult to compare the results of studies that employ different measurement tools with any level of confidence. Another challenge when reviewing SES is that even within SES focused studies there is often an over representation of participants from a higher SES background. What is difficult in research involving socioeconomic status is that it is often limited in its economic range within testing, meaning that the SES under investigation is not indicative of the true range of SES possible, but rather a small sampling of the higher end of the socioeconomic continuum (Hoff, 2003).

Beyond the commonly used income, education and occupation factors, research suggests that neighbourhood factors are also important when considering the implications of SES on health outcomes (Pickett and Pearl, 2001). There are a multitude of neighbourhood factors that can influence health outcomes, including factors such as the availability of health services, access to parks, access to healthy and affordable food, presence of stress, and the availability of social support (Pickett and Pearl, 2001). Moreover, neighbourhood factors have been found to have an effect on health independent of socio-demographic characteristics and socio-economic risk (Ross et al., 2004). It follows that a more accurate approach to the measurement of SES in a health research context, would capture factors that reach beyond occupation and education, and allow for the inclusion of more social and situational measurements. For the purposes of this thesis, the Scottish Index of Multiple Deprivations was used as the measure of SES.

1.3.1 SIMD 16

The SIMD 2016, or Scottish Index of Multiple Deprivations, is a multilevel tool developed and used by the Scottish government to capture area level deprivation (Scottish Government, 2016). The SIMD is a residential post-code based measure, meaning that it uses geographical areas to identify geographic concentrations of deprivation. Scotland is divided into 6,976 data zones, each containing approximately 760 people. These data zones are able to be ranked from most deprived (rank 1) to least deprived (rank 6,976). The SIMD is a relative measure of deprivation which means that the ranks are able to be compared but cannot determine how much more deprived one zone is from another. Moreover, the SIMD identifies deprived areas, not deprived people, and it is worth noting that not everyone who is deprived will live in a deprived area (Scottish Government, 2016).

The SIMD is a multilevel tool and uses seven domains to form a collective measure of deprivation. The seven domains are current income, employment, health, education skills and training, geographic access to services, housing, and crime. The income domain is a measure of the percentage of people living in a postcode area who are income deprived and receive benefits or tax credits. Similarly, the employment domain is a measure of the percentage of working aged people who are employment deprived. The health domain measures hospital stays, specifically hospital stays related to alcohol or drug misuse, emergency stays, proportion of population being prescribed drugs for mental health concerns, and the proportion of low birth weight births. The education domain measures school pupil attendance, and proportion of pupils attending higher education. The housing domain measures the percentage of people living in households that are overcrowded or have no central heating. The access domain measures the average drive time and public transport time to services such as petrol stations, GP surgery, post office, schools and retail centres. The crime domain is a measure of the recorded crimes in the area including sexual offences, domestic housebreaking, vandalism, drug offences, and common assault. For more information on what exactly goes into each domain measurement see figure 1-1. The remainder of this chapter will consider the developmental consequences of low SES, in order to then consider how prematurity and low SES may interact.

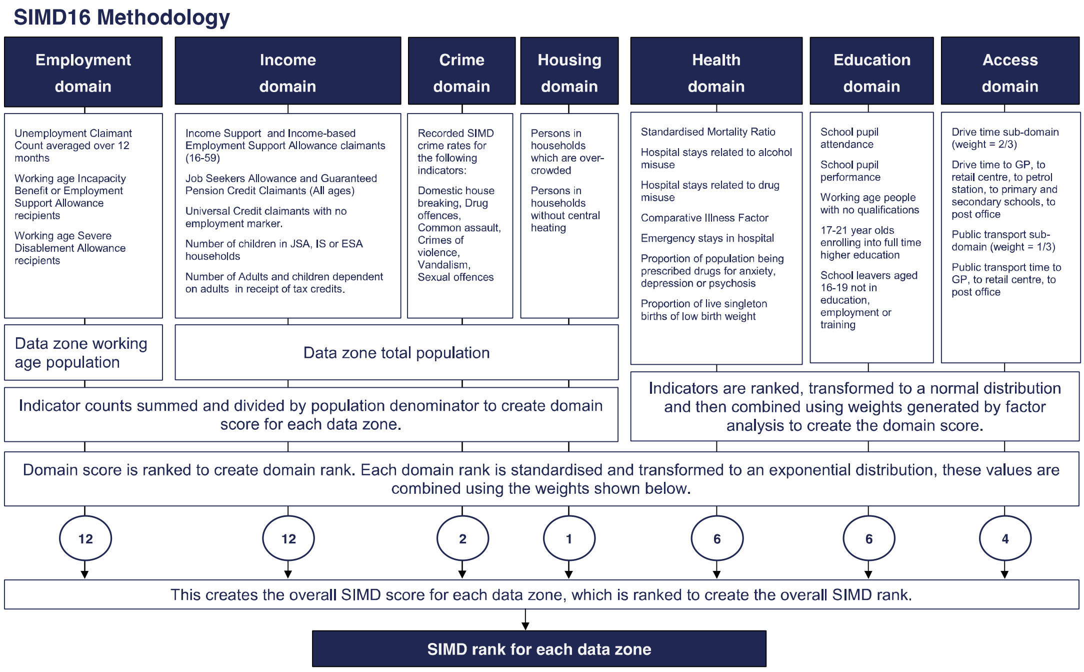

Figure 1-1 SIMD 16 Methodology. Reproduced with permission from the Scottish government

1.4 Socioeconomic consequences on development

There is significant evidence examining the developmental sequelae associated with growing up in a lower SES environment. In fact, many of the observed effects of prematurity on development are mirrored by the effects of deprivation on development. Development is a dynamic process through which many contributing factors interact with one another. As previously mentioned, SES is a difficult construct to measure and it encompasses a wide array of factors unable to be separated. It is difficult if not impossible to fully unpack the relationship between something as complex as SES and development. Nevertheless, I will briefly review some of the literature suggesting associations between the two.

1.4.1 Birth outcomes and maternal effects

Some of the effects of SES begin prenatally and immediately postnatally, with low SES infants more likely to have adverse birth outcomes. Zeka and colleagues found that mothers who received inadequate or intermediate prenatal care were at increased risk of preterm delivery (Zeka et al., 2008). Moreover, mothers from lower SES neighbourhoods were more likely to experience adverse birth outcomes (Zeka et al., 2008). Studies have shown that SES is also related to birthweight, with mothers from lower SES backgrounds more likely to have an infant with a low birthweight (Metcalfe et al., 2011). Zeka and colleagues also found maternal educational attainment correlated with birth outcomes, and mothers with college or post graduate education were associated with a higher birthweight, while mothers with less than twelve years of schooling were at a greater risk for preterm birth (Zeka et al., 2008). The effects of SES on mothers goes beyond preterm birth and has also been found to have a more direct impact on maternal health. Goyal and colleagues found that low SES mothers displayed more depressive symptoms in their third trimester compared to mothers of a higher SES (Goyal et al., 2010). While both groups displayed similar levels of depressive symptoms one month following the birth of their first child, low SES mothers were again found to have more depressive symptoms at two and three months post-natal (Goyal et al., 2010). The authors suggested that these results could be explained by a lack of resources potentially experienced by the low SES mothers.

1.4.1.1 SES and preterm labour

Lower SES is associated with higher levels of stress, higher infection rates, and poor nutrition in pregnant women (Hackman et al., 2010). Mothers from a low SES are at a significantly higher risk of preterm delivery (Bonet et al., 2013; Mehra et al., 2019; Peacock et al., 1995). While it is clear from the literature that there is an important relationship between SES and preterm birth, the mechanism through which it operates remains unclear. Research suggests that stress is a likely risk factor for preterm birth, and that women from lower SES backgrounds are more likely to experience increased stress levels (Copper et al., 1996). Moreover, birthweight has been associated with stress, with women experiencing higher levels of stress having babies with a lower birthweight, regardless of delivery date (Lobel et al., 1992). While much of the evidence surrounding socioeconomic status and preterm delivery is focused on the US health system, the relationship between SES and increased risk of preterm delivery is seen in many other western countries including Canada and the United Kingdom (R et al., 1991; Smith et al., 2007). Moreover, this effect is observed within countries with substantially different health care systems and levels of support, suggesting that neighbourhood socioeconomic factors may have an important relationship with preterm birth beyond a single mechanism such as poor access to maternal care (Bonet et al., 2013). What is more likely is that the relationship between preterm birth and SES is a reflection of multiple pathways through which low SES is related to an increased likelihood of preterm delivery.

1.4.1.2 Neurological consequences of low SES

Similarly to the neurological differences observed in infants born prematurely, socioeconomic effects have been observed in the growth and development of infants. Infants from a lower SES home have been found to have smaller cortical grey and deep grey matter volume (Betancourt et al., 2016). In this study, infants were scanned early after birth, at 5 weeks of age, and results were independent of birth weight, suggesting that SES may have an early impact on brain development. It is important to note that the sample only included African-American female infants, thus limiting the generalizability of the results. In another study, Hanson and colleagues also observed important neurological differences in infants from low SES homes (Hanson et al., 2013). The authors found that infants from low SES homes had lower volumes of grey matter in the frontal and parietal lobes and slower growth trajectories during infancy. These results add to the evidence suggesting that the SES environment has an important early influence on infant brain development.

In addition to observed SES effects, parental education specifically has been found to have a linear relationship with children's total brain surface area, with increases in parental education associated with increases in children's brain surface area (Noble et al., 2015). Noble and colleagues highlight that while there is clearly a relationship between SES and brain structure, it is not clear what drives this association, and they stress caution in interpreting any results, as there are many other factors involved in brain development outside of environmental influences. However, despite the difficulty in interpreting causality in results, it is clear that SES is related to neurological development. In an earlier study, Noble and colleagues found SES related differences in hippocampus and amygdala volume, even when controlling for age, as well as differences in total cortical volume and gender (Noble et al., 2012). The authors suggested that these observations reflect the differences in later language, memory and socio-emotional processing development which have been linked to SES and will be discussed at a later point in this chapter. The authors recognized that it is difficult to draw conclusions with a small sample size and a lack of known environmental factors, such as exposure to stress or language, that may have affected the results. Tomalski and colleagues found that measures of low SES, here defined by low income and maternal education, were associated with reduced EEG activity over the frontal areas of the brain (Tomalski et al., 2013). The authors suggested that this lower activity may be indicative of an increased risk of later language difficulties or later difficulties with attentional control.

1.4.1.3 Early cognitive outcomes

Similarly to prematurity, low SES has a profound and complex relationship with cognitive development and the effects of SES are not limited to early neurological differences. Beyond birth, infants and children from low SES backgrounds exhibit altered and often non-optimal developmental outcomes (Currie and Goodman, 2020). Vital cognitive systems such as language, executive function, and attention and memory have all been found to be influenced by SES (Sarsour et al., 2011). Language development specifically will be discussed in the second chapter of this thesis.

Tacke and colleagues observed the early exploratory behaviours of infants and found that infants from a low SES household displayed typical development on simple exploratory behaviours (Tacke et al., 2015). However, they also found that low SES infants showed less selectivity during exploration and a different developmental trajectory than their high SES peers. Low SES infants were less likely to tailor their exploratory behaviours, which the authors suggested may be indicative of low SES infants having difficulty transitioning into more advanced kinds of object and environment exploration (Tacke et al., 2015).

Clearfield and colleagues observed 6-month-old infants using a perseverative reaching task. Low SES infants displayed higher rates of inattention at 6, 9 and 12 months than high SES peers (Clearfield and Niman, 2012). The authors suggest that this could be indicative of later school related problems caused by attention regulation difficulties. Low SES infants have addionally been observed to have a delayed pattern of cognitive flexibility compared to term born controls, and were also found to display a decreased attention to people vs. objects. Clearfield and colleagues suggested that this may be indicative of a delay in early social learning, though it is worth noting that the study is limited by its restricted two category measurement of high vs. low SES and a small sample size (Clearfield and Jedd, 2013).

1.4.1.4 Memory and stress

Low SES infants have been observed to have less advanced working memory and inhibitory control than high SES peers (Hackman and Farah, 2009). This trend is found to remain as children grow older, with similar SES related effects on working memory, cognitive control and language found in children aged 10-13 (Farah et al., 2006). Low SES is also associated with increased levels of stress, including parental stress, which itself is associated with dysfunction in stress response systems in children (Hackman et al., 2010). Lower income parents have increased stress that may limit their time and energy available for play with their children (Milteer et al., 2012). Additionally, lower SES children are more likely to experience stress themselves, which has important health consequences later on in life (Shonkoff et al., 2009). Children living in poverty were found to have increased salivary cortisol at 7, 15, and 24 months compared to higher SES peers (Blair et al., 2011). This is concerning given the known evidence which suggests that stress has important implications for later cognition, including on learning, memory and executive functions (Lupien et al., 2007).

1.4.1.5 Executive function outcomes

Childhood SES has been found to have large effects on language and executive function (Hackman et al., 2010). Researchers have found inequalities in the executive function abilities of children from high and low SES households (Sarsour et al., 2011). The authors in this study accounted for differences in attentional skill and reading ability in analysis, suggesting that the observed differences in more advanced executive functions are a true reflection of differences in inhibitory control and cognitive flexibility (Sarsour et al., 2011). In an EEG study by Kishiyama and colleagues, low SES children were observed to have reduced performance on measures of executive function (Kishiyama et al., 2008). Additionally, low SES children had reduced prefrontal activity in measures of attention, which is similar to patterns observed in patients with lateral prefrontal cortex damage (Kishiyama et al., 2008). On measures of executive function, including working memory, cognitive flexibility, and semantic fluency, low SES children had lower scores compared to children from a high SES background. The authors suggest that these observed differences could be due to environmental effects, such as increased levels of stress or less cognitively stimulating environments experienced by children from a low SES (Kishiyama et al., 2008).

In their study looking at the cognitive outcomes of 60 children around 5 years of age, Noble and colleagues found significant SES effects on both language and executive function (Noble et al., 2005). Interestingly, regression analysis showed that SES and executive function scores predicted language ability, but that SES did not have an independent effect on executive function over and above what was predicted by language ability. The authors suggest that this could be indicative of a causal pathway between SES, language and executive function whereby SES has an effect on language which then, independently, has an effect on executive function abilities.

Given the reported differences in neurocognitive outcomes, it’s not surprising that children from low SES households are found to have less optimal school outcomes. Children from higher income families are found to have higher educational attainment, even when controlling for parental levels of education (Case et al., 2005). Parental levels of education were found to be strongly associated with children's level of schooling, in that mothers who left school early had children who passed less advanced exams than mothers who remained in school for longer periods of time, though this study did not control or potential shared determinants such as IQ (Case et al., 2005).

1.4.2 Interactions and overlap between SES and prematurity outcomes

There are significant interactions between SES and prematurity with effects on infant outcomes. Research has suggested that differences in SES may act as a moderator for prematurity and certain developmental outcomes (Potijk et al., 2013). Low SES and prematurity can often be thought of as "separate risk factors with multiplicative effects on developmental delay" (Potijk et al., 2013). Increased risk in domains such as fine motor skills, social skills and communication are observed both in low SES and preterm populations, suggesting that preterms from a low SES may be at an even greater risk of delays in these domains (Potijk et al., 2013).

Given the significant evidence suggesting mothers from a low SES are at an increased risk of preterm birth, the preterm population is over-represented on the lower end of the SES spectrum (Bonet et al., 2013). Thus, developmental delay effects in preterm populations may, in some cases, be a reflection of low SES effects. In addition, low gestational age at birth and low SES have been found to have both independent and multiplicative effects on development (Linsell et al., 2015). Both are known to be associated with increased behavioural and emotional issues in school age children, and low SES preterm children may be at an increased risk compared to high SES preterm children (Potijk et al., 2015). Quigley and colleagues found children whose mothers had lower educational attainment had lower school achievement. When prematurity was added into the model it had a significant additional impact (Quigley et al., 2012). Another study found that neighbourhood deprivation modifies the increased risk of test failure in preterm infants, with authors once again suggesting that low SES preterm infants may be considered a “double-jeopardy” group at an even more increased risk (Richards et al., 2015). It appears as though SES has significant additive impact on long term outcomes experienced by preterm infants (Ene et al., 2019; Johnson et al., 2015)

There is also significant overlap in the domains affected by both prematurity and SES. As mentioned previously in this chapter, both low SES and prematurity are associated with increased rates of maternal depression (Goyal et al., 2010; Vanderbilt et al., 2009). In addition, both low SES and prematurity are associated with adverse cognitive outcomes and poorer school performance (Bhutta et al., 2002; Case et al., 2005; Currie and Goodman, 2020; Quigley et al., 2012). Another domain jointly affected by prematurity and SES is language development, which chapter 2 will explore in detail.

1.5 Chapter summary

In this chapter, I’ve shown that prematurity can have significant developmental consequences. Through a review of the literature I’ve demonstrated that SES interacts with prematurity in at least three ways; low SES is associated with an increased rate of preterm labour, SES interacts with the consequences of prematurity, and SES and prematurity independently cause similar types of negative outcomes. Specifically, lower gestational age and lower SES are both associated with adverse outcomes across cognitive developmental domains. In the next chapter I will demonstrate that the communication domain is no exception, and that both prematurity and low SES can have significant and profound influences on infant language development.

2 The effect of prematurity and socioeconomic risk on infant language development

2.1 Outline

In the previous chapter I showed that prematurity and SES have important implications on development, and briefly mentioned that the language domain is no exception. Therefore, in this chapter I will review typical language development prior to reviewing the language development of preterm infants and infants from low SES backgrounds, with a view to determining the most important questions to address at this intersection of prematurity, SES, and language development.

2.2 Typical Language Development

The pre-linguistic period, where the infant is not yet speaking, nevertheless includes many important developmental milestones. Shortly following birth, infants display a preference for maternal voice and are able to distinguish between the voice of their mothers vs. the voice of a stranger (Hepper et al., 1993). Vocalisation of preverbal infants is typified by crying and vegetative sounds such as sucking and burping (Stark et al., 1975). Crying is the first vocal way an infant is able to communicate distress and elicit caregiver attention (Acebo and Thoman, 1995). At 2 months old infants typically begin cooing, which is followed by babbling between 3 and 6 months (Cusson, 2003). These early pre-linguistic behaviours are vital stages of development and lay the foundations for the acquisition of later, and more advanced, communication skills.

Babbling is considered a key developmental milestone, and is considered an important early speech-like vocalisation (Oller and Eilers, 1988). Babbling starts off as monosyllabic and is followed by canonical babbling, which is the production of a string of repeated syllables such as “ba ba ba” (Oller and Eilers, 1988). Canonical babbling is an important phase of development as it signifies the infant’s ability to form full syllables, which is imperative for successful language. Canonical babbling has been closely linked with the onset of rhythmic hand banging, with hand banging correlating with the emergence of first words but not to other motor milestones (Bates and Dick, 2002). Both canonical babbling and rhythmic hand banging can occur outside of communication, which means that they can occur when the baby is alone, as well as when around others (Bates and Dick, 2002). Infants who exhibit delayed canonical babbling are at an increased risk of significant delays in later language (Oller et al., 1998).

Infants are incredibly sensitive to their language environment, and by 5 months are able to differentiate between linguistic rhythms, showing a keen awareness to their linguistic surroundings (Nazzi et al., 2000). At around 9 months infants begin to show some early understanding of words (Bates & Dick, 2002). Comprehension of language, also referred to as receptive language, occurs before the development of expressive language (Cusson, 2003). The development of word comprehension is correlated with the emergence of deictic gestures in infants (Bates and Dick, 2002). In infants and young children, deictic gestures include movements of giving, showing and pointing. At this point in development, cultural gesture routines such as waving also begin to occur (Bates and Dick, 2002).

Just before the emergence of first words, children begin replicating object centred actions, such as bringing a cup to their lip (Bates and Dick, 2002). Action gestures such as these are often associated with the emergence of vocal naming (Shore et al., 1990). This “gestural naming period” is temporary, and disappears as oral language development and functional communication skills develop (Bates and Dick, 2002). From 7.5 months onwards, infants begin to show speech segmentation skills and can attend to familiar isolated words within fluent speech (Newman et al., 2006).

First words typically appear around 1 year of age, and by 18 months word production and comprehension are developing rapidly (Acredolo & Goodwyn, 1988; Rowe & Goldin-Meadow, 2009). Around 18-20 months children begin to put together simple 2-3 word phrases and a significant volume of adult language is comprehended (Bates and Dick, 2002). These early word combinations are also associated, and sometimes preceded by, early gesture-word combinations, such as pointing while naming (Iverson et al., 1994). By 24 months, approximately half of infants expressive language can be understood (Cusson, 2003). Infants receptive language skills, or their ability to comprehend language, develop faster than expressive language ability, or their ability to verbally communicate with speech, and this pattern remains throughout language development (Cusson, 2003). Throughout the second year of life, infants recognise and respond to adult words with increasing frequency and accuracy, becoming better able to recognise and interpret words in different contexts (Fernald et al., 2006). By 3 years of age children can typically use 4-5 word sentences and have a vocabulary of approximately 1,000 words (Cusson, 2003). By 4-5 years of age, all speech produced by children is understandable, complete sentence structure is present, and vocabulary is several thousand words large (Cusson, 2003).

2.2.1 Importance of early gesture development

Gesture production predates speech and can be used to predict later language production (Bates, 2014; Iverson and Goldin-Meadow, 2005). Children who gesture more have larger vocabularies at later points in development, and researchers have suggested that a low gesture rate might negatively influence children's later communicative abilities (Acredolo and Goodwyn, 1988; Rowe and Goldin-Meadow, 2009). That said, some studies have found this relationship between language and gesture to be less straightforward. Bavin and colleagues found that early gesture behaviours at one year of age was a stronger predictor of vocabulary comprehension compared to vocabulary production (Bavin et al., 2008). Similarly, Westerlund and colleagues found that early gesture production was not an effective predictor of later language use (Westerlund Monica et al., 2006).

That said, significant evidence suggests that early gesture can have important effects on language development (Iverson and Goldin-Meadow, 2005). The emergence of deictic gestures discussed above serves as an important opportunity for infants to seek out linguistic input from their caregivers, and affords infants the opportunity to communicate information that they are unable to express with speech (Iverson and Goldin-Meadow, 2005). While some studies have not found pointing to be strongly predictive of later language production, pointing is positively correlated with language comprehension development (Zambrana et al., 2013). A recent meta-analysis found a strong relationship between pointing and language development, with pointing acting as both a means of communication, while also playing a supporting role in later language development (Colonnesi et al., 2010). Even before children are able to produce two word combinations they are able to express two word ideas through the use of gesture/speech combinations, suggesting that gesture is playing an important developmental role that is independent of verbal language (Butcher and Goldin-Meadow, 2000; te Kaat- van den Os et al., 2015).

2.2.2 Theories of Language Development

There are numerous competing and complimentary theories of language development. While I don't propose to test the predictions of these competing theoretical accounts, they provide a useful context for our understanding of language development, especially the relations between parent and child language. The process of language development remains an important and often controversial area of research. An early theory of language posited that language is a learned behaviour and develops along the same pathway as any other learned behaviour (Skinner, 1986). According to this learning theory, adults can foster infant language development by using positive reinforcement to help support and encourage infant vocalisations. The main criticism of this theory is that it does not account for the speed at which language development occurs, nor the creation of novel speech sounds (Chomsky, 1959). Other theories, argue that language is an inherent process present in all humans (Chomsky, 1959). Chomsky suggested that there is a biological origin of language, that he termed the "language acquisition device" that allows language development to function as an innate ability.

More social interactionist based theories of language development propose that language development occurs as a result of an interaction between both biological capabilities and environmental influences (Chapman, 2000). According to this approach, language is learned as a result of an infant's cognitive capabilities, as well as the social language environment in which they grow up. This approach to language development employs an interaction between the capabilities of the child, such as the ability for object exploration and joint attention, and the linguistic environment provided by the parent (Haebig et al., 2013). This approach employs an ecological model of child development, whereby child development occurs through a mechanism involving both proximal and distal resources (Bronfenbrenner, 1986). In the case of language development, neurobiological and genetic resources can be classified as proximal, while maternal and familial environment can be considered distal resources (Zubrick Stephen R. et al., 2007). In fact, significant evidence exists as to the importance of both individual differences and parental input in early childhood language development.

2.2.3 Individual Influence on Language Development

Research has shown that early infant preverbal abilities relate to later language abilities. Infant gesture vocabulary is a strong predictor of later verbal vocabulary, while infant gesture and speech combinations predict later verbal sentence complexity (Rowe and Goldin-Meadow, 2009). Similarly, Sauer, Levine & Goldin-Meadow looked at a sample of children with pre and perinatal brain lesions, and found that children who displayed delays and deficits in gesture production at 18 months also displayed lower vocabulary scores at 30 months; suggesting a relationship between early gestural development and subsequent language learning (Sauer et al., 2010). While there are always significant individual differences in language development, studies have shown that infants who have better language performance on earlier language measures show larger expressive lexicons at 2 years of age (Newman et al., 2006). Moreover, infants who have more advanced segmentation skills, which means they are able to identify single words embedded in fluent speech, demonstrate higher scores on later language outcome measures

(Newman et al., 2006). Early language processing skills have been shown to predict vocabulary growth, with quick and reliable early language processing associated with better later language outcomes (Fernald et al., 2006). Language processing at 18 months is also found to predict receptive vocabulary at 3 years (Marchman et al., 2016). Children, between 12 and 18 months, who display more joint engagement during parent child interaction have been found to have larger vocabularies than children who showed less engagement, though this study was limited by a small sample size (Tomasello and Todd, 1983).

2.2.4 Parental Influence on Infant Language Development

It has been suggested that children's language learning is facilitated through interactions with adults and the establishment of early labelling and language "routines" (Acredolo and Goodwyn, 1988). Schmidt and Lawson argued that parents use a combination of gesture and speech to "encourage children to orient to aspects of the environment", and that parental gesture helps to foster children's joint attention skills (Schmidt and Lawson, 2002). Additionally, they found that infant exposure to gesture paired with relevant speech, helped predict later language outcomes. Other researchers have reported similar connections between parent gesturing and children's later language development, with maternal pointing positively correlating with children's later vocabulary size (Iverson et al., 1994). Likewise maternal gesturing is associated with children's comprehension vocabulary, with more maternal gesturing associated with increased word learning in children (Zammit and Schafer, 2011). Moreover, mothers who communicate more with their children, through a higher volume of speech and gesture, elicit more respective communication from their children (Iverson et al., 1994). Given the intricate connections between speech and gesture, it appears as though the more exposure a child receives to both, the better their later language outcome (Iverson et al., 1994). It is important to note that many developmental gesture studies are often limited by a small sample size, rendering it difficult to make predictions that are generalizable to a more global sample, and limiting the robustness of the results (Iverson et al., 1994).

Nevertheless, the evidence for a relationship between parent and infant interaction and language learning is compelling. From the initial stages of infant development, mothers begin to adapt their language to be more suitable for interacting with infants and young children. This adapted language, dubbed motherese, is characterized by being higher in pitch, containing short utterances, speaking slowly and with longer pauses, and includes simplified syntax and increased repetition. Some research has shown that this form of communication may facilitate infant language learning (Nelson et al., 1989). In addition, evidence suggests that caregivers increase infants receptive language skills by verbally responding to infant gesture, translating gestures into speech (Romano and Windsor, 2020). Moreover, caregivers influence infant gesture development by modelling gestures and paring together gesture and speech (Romano and Windsor, 2020).

Mothers who are more verbally responsive during play are observed to have children with higher levels of expressive and receptive language at 13 months, suggesting that word learning is facilitated through maternal and infant joint engagement (Nelson et al., 1989). Increased levels of joint engagement between mothers and children are associated with larger comprehension vocabularies (Carpenter et al., 1998), and volume of word types in maternal speech is related both to children's receptive and expressive vocabularies (Bornstein et al., 1998). Evidence suggests a relationship between parent responsiveness and infant language learning, and the quantity, richness, and complexity of maternal speech have all been specifically found to benefit the lexical development of young children (Hoff and Naigles, 2002).

It is worth noting that parent child interaction can vary across cultures and there are significant cultural variabilities in an infant's language learning environment (Mastin and Vogt, 2016). For example, in some communities, adult speech is rarely directed at preverbal infants directly, and infants across cultures experience different levels of triadic interaction (Brown, 1998; Salomo and Liszkowski, 2013). Thus, the argument can be made for a variety of different pathways through which infants learn language, such as learning through observation of adult speech rather than direct dyadic interaction (Shneidman and Goldin-Meadow, 2012).

2.3 Prematurity and Language Development

As discussed in chapter 1, prematurity confers a wide range of risks. Language risks are also prevalent in the preterm population, and the following section will focus specifically on these communication risks.

2.3.1 Prematurity and Language

Language impairment is typified by delays in lexical and grammatical development that cannot be attributed to significant sensory or neurological impairment (Sansavini et al., 2010). There is mixed evidence regarding the pre-linguistic behaviours of infants born prematurely. One study found that preterm infants did not display a delay in the onset of canonical babbling but did produce fewer later vocalizations and showed a delay in first word production (Törölä et al., 2012). Other researchers have found that preterm infants are slightly earlier than term born peers in the onset of canonical babbling and rhythmic hand banging, which would suggest an advantage for later language learning (Eilers et al., 1993). It has been argued that this result should be interpreted with caution, as preterm infants may display an earlier onset but that canonical babbling in the preterm population may not be as stable as it is in the full-term population (Oller et al., 1994). Benassi and colleagues found a delay in early gesture production in very early preterms, and proposed that early disruptions into pre-linguistic behaviours, such as early gesturing, may have negative outcomes on related domains, such as later language development (Benassi et al., 2016).

2.3.2 Language development in children born preterm

Given the importance of early language development on later school success, it follows that much research has been dedicated to the early identification of language difficulties and delays in the preterm population. By examining the differences in early language milestones such as vocabulary and receptive language skills, researchers can attempt to identify early disparities in the development of foundational language building blocks. There is mixed evidence regarding the pre-linguistic behaviours of infants born prematurely. De Schuymer and colleagues observed delays in the preverbal skills of preterm infants, such as gaze following and pointing, as well as later delays in expressive and receptive language, when compared with infants born full term (De Schuymer et al., 2011). Preterm children have also been found to produce fewer gesture and word combinations at 18 and 24 months compared to children born full term, suggesting that delays and impairments due to prematurity extend beyond the pre-linguistic stage (Suttora and Salerni, 2011).

In one study, two year old preterm children were found to have a similar vocabulary score range as full-term peers, but that the preterm population was overrepresented at the lower end of the range (Foster-Cohen et al., 2007). In addition, there was a relationship between gestational age at birth and vocabulary scores, with lower gestational age associated with lower vocabulary. Gestational age was also found to have a relationship with decontextualized word use, with lower gestational age associated with a lower likelihood of using language in decontextualized ways (Foster-Cohen et al., 2007). It appears as though prematurity may be related to language development across the early lifespan. Moreover, the variability of language outcomes within the preterm population argues for the importance of looking at individual differences within the population, and suggests that, while the preterm infants may be generally more at risk for language delay, there is significant variability within the preterm population itself which warrants futher investigation.

On a test of verbal fluency at early school age, very preterm children, with a gestational age less than 30 weeks, were found to perform worse than term born peers, and group differences were not attributable to differences in IQ, or maternal education (Aarnoudse-Moens et al., 2009). At 5 years of age, preterm children perform significantly poorer on measures of language comprehension, production and speech abilities than aged matched peers. These differences remained significant even after removing children with major neurological disabilities from analysis (Luoma et al., 1998).

Cattani et al found that preterm children exhibited global delays in language development, including gesture production, word comprehension and word production (Cattani et al., 2010). A meta-analysis by Barre and colleagues found that preterm and extremely low birthweight children performed less well than term peers on measures of expressive and receptive language, and that these differences were apparent in school age children (Barre et al., 2011). This suggests that the effects of poor language ability in preterm children may persist later on in development (Sansavini et al., 2010).

Foster-Cohen and colleagues compared children at 4 years of age who were born very preterm with term born peers (Foster-Cohen et al., 2010). They found that children born very preterm had lower scores on both receptive and expressive language measures. Moreover, the preterm infants displayed a poorer performance on measures of story recall and labelling, and producing appropriate grammatical forms. Preterm infants showed performance differences of larger effect in receptive language skills than expressive language, and these results remained significant after controlling for severe neurosensory impairment (Foster-Cohen et al., 2010). Interestingly, group differences between term and preterm language scores were smaller when controlling for social risk factors such as SES, suggesting that language outcomes seen in preterm populations may be in part a reflection of poorer SES in that population. That being said, preterm infants still displayed significant differences on receptive and expressive language even after controlling for social risk, which indicates a prematurity specific impact on language outcomes (Foster-Cohen et al., 2010).

2.3.3 Direct impact of prematurity on infant language

There are numerous mechanisms through which prematurity is thought to impact language development. Immediately following birth, preterm infants are exposed to significantly increased levels of noise, which has been found to have immediate negative health consequences on preterm infants (Wachman and Lahav, 2011). High levels of sound have been shown to affect infants' stress levels, which can in turn adversely affect development (Philbin, 2000).

While some studies suggest that language development delays have a relationship with prematurity independent of demographic factors (Woodward et al., 2009), others have suggested that there may be a mediating factor associated with prematurity that may often be unaccounted for. Wolke and colleagues assessed general cognitive ability as well as language skills in preterm and term born peers (Wolke et al., 2008). Extremely preterm children were more likely to display cognitive impairment and poorer performance on language tests. After controlling for cognitive performance, there were no significant language issues in the preterm population, suggesting that differences in language abilities may actually be evidence of general cognitive deficits in the preterm population (Wolke et al., 2008).

2.3.4 Indirect impact of prematurity on infant language via parental input

Some researchers have suggested that, given the importance of early input for later language development, some of the observed differences between preterm and term children may be due to very early experiences. Infants are exposed to vital maternal sounds during both the pre-and postnatal periods. Moreover, early language exposure can have a significant impact and positive effect on preterm growth and neurodevelopment (Best et al., 2018). Infants born preterm are exposed to less maternal voice and increased levels of noise due to their experience in the neonatal intensive care unit, or NICU. Exposure to parental vocalizations is a strong predictor of infant vocalizations at 32 weeks and conversational turns at 32 and 36 weeks, compared to language input from other adults (Caskey et al., 2011). Higher adult word count in the NICU is also associated with higher infant language scores at 7 months and higher expressive communication scores at 18 months, suggesting that early language input can have long lasting implications (Caskey et al., 2014). The effects of prematurity on infant language development will be explored further in chapters 4 and 6.

2.4 Effect of Socioeconomic Status on Infant Language Development

In addition to the increased risk observed in the preterm population, there is significant evidence suggesting that SES can have wide and lasting impact on infant language development. There are many mechanisms through which SES has been thought to affect infant language development and it is difficult to unpick the exact relationship between the two. To begin, I will review some of the literature addressing the observed relationship between SES and language development. Following this, I will briefly address some of the proposed pathways through which this relationship operates.

When beginning to speak, children from low SES backgrounds have smaller expressive vocabularies than high SES peers (Fernald et al., 2013). This difference is apparent as early as 18 months and continues to be significant at 24 months (Fernald et al., 2013). In a hallmark study of SES and language, 3-year-old children from a high SES household were found to have double the number of words in their vocabularies as low SES children (Hart and Risley, 1995). Additionally, children from low SES homes exhibit slower rates of vocabulary growth (Blanden and Machin). Studies have reported a positive correlation between SES and vocabulary growth in children, with high SES associated with increased vocabulary development (Arriaga et al., 1998), and children from lower SES homes exhibiting a slower rate in language production growth (Pungello et al., 2009).

In addition to language production, more complex syntactic and phonological development also appears to be affected by SES; with SES serving as a predictor of lexical, constituent and clausal diversity production (Huttenlocher et al., 2010). Children from high SES exhibit higher levels of phonological awareness, which means they have an increased sensitivity to phonological structures (McDowell

Kimberly D. et al., 2007). Phonological awareness has important implications for later reading success, which makes early SES related differences all the more significant. In fact, children from a lower SES are at a significantly higher risk for developing reading difficulties across school age (Kieffer, 2010).

2.4.1 Direct impact of SES on infant language

Similar to what was seen in the previous section examining the effects of prematurity on language, SES can have a wide impact on child development from very early on in the process. There is evidence suggesting SES related neurological differences in the left superior temporal gyrus and left inferior front gyrus, both of which are important language supporting areas of the brain (Noble et al., 2012). In infancy, low SES infants display less oral and manual object exploration than their full-term peers, which is considered an important pre-linguistic developmental stage (Clearfield et al., 2014). Early gestural differences in low SES infants have also been observed, with children from low SES families producing less gesture to communicate meaning (Rowe and Goldin-Meadow, 2009). As early gesture is a known predictor of later language performance, these early observed differences between high and low SES children are notable (Rowe and Goldin-Meadow, 2009).

2.4.2 Indirect impact of SES on infant language via parental input and resource access

As SES is a multifaceted and nebulous construct, there are numerous theories on how it affects language development. Here we will provide a brief overview of two of the most common mechnisms by which SES is posited to affect development; namely through language exposure and resource access.

Children from a low SES background are exposed to less language than children from high SES homes (Hart and Risley, 1995). Studies have found that mothers from a low SES use shorter mean length utterances (MLU) than mothers from high SES backgrounds (Hoff, 2003). This is consequential as the children in this study who were exposed to longer utterances displayed a faster rate of vocabulary growth (Hoff, 2003). Additionally, this study concluded that maternal speech was a mediating variable between SES and children's vocabulary development, and found that any differences between children's later vocabulary outputs could be explained by differences in maternal communication. Lexical complexity and diversity in maternal speech has also been found to relate to SES, and exposure to child-directed speech has been found to act as buffer in children from low SES who are at a higher risk for poor language outcomes (Huttenlocher et al., 2010; Vernon-Feagans and Bratsch-Hines, 2013). Rowe found that mothers with a higher level of education had a higher level of pointing, specifically using their pointing gesture to direct conversations and focus attention (Rowe, 2000). This builds upon previous research suggesting that pointing can help to establish joint attention between parents and children, which in itself is important for language development (Iverson et al., 1994).

SES is also thought to affect development due to a lack of access to resources (Bradley et al., 2001). Children from a low SES often have access to fewer cognitively stimulating toys and books, which can have important consequences, given that the number of books a child has access to is significantly related to later expressive vocabulary (Johnson et al., 2008). Additionally, children from a high SES are more likely to have access to cognitively stimulating experiences such as museums and theatre, than children from a low SES home (Bradley et al., 2001). Among a low SES population, maternal employment was found to be positively associated with literacy environment, which itself was associated with children's later developmental outcomes (Rodriguez et al., 2009). In addition to resource availability, environmental factors of SES can also affect language development opportunities. If low SES children are in an unsafe neighbourhood or have limited access to outdoor space, it can be difficult or dangerous to play outside, which can have important consequences for cognitive development (Rodriguez et al., 2009). The effects of SES and language development will be explored further in chapters 5 and 6.

2.5 Resilience

Despite the potentially bleak picture of the relationship between low SES and children's development, it is important to remember that SES related effects, while profound, are not impenetrable. There have been a few SES related interventions that have had positive results in mitigating the increased risk of growing up in a low SES environment, that also help to reveal the mechanism of the relationship between SES and language outcomes.

Ridge and colleagues placed signs around a grocery store, designed to provoke conversations between parents and children (Ridge et al., 2015). Signs contained simple questions like "what's your favourite vegetable", or "where does milk come from". In stores without signs, families in stores catering to low SES customers spoke less than families from mid SES stores. Low SES stores that did have signs saw a significant increase in adult child conversations, with rates of conversation comparable to those observed in the mid SES stores (Ridge et al., 2015). Although unable to determine long term language effects, this study suggests possible low-cost ways to encourage richer language exchanges and foster language growth. In addition, interventions targeted towards parents often focus on educating caregivers on the importance of early and consistent language input (Pace et al., 2017). Interventions focused on language and reading, as well as alphabetic skills and writing, have all been found to have positive effects on children as young as 3 years of age (Aram and Biron, 2004; Levin and Aram, 2012). Programs providing children's books to families, and encouraging shared reading practices, such as the Reach out and Read program (Sharif et al., 2002), and the Scottish Book Trust's Bookbug program, have shown significant improvements on the caregiver attitudes of shared bookreading (Golova et al., 1999). Such interventions have seen significant improvements in children's vocabulary development (Sharif et al., 2002).

Other interventions have looked at targeting parent behaviour. In the Video Interaction Project, parents review taped sessions of their parent child play with a child development expert who provided observations and suggestions for activities and play to do at home (Mendelsohn et al., 2007). Children enrolled in the program were found to have improved cognitive and language outcomes and parents were found to have reduced parenting stress (Mendelsohn et al., 2007).

Other interventions targeting low SES children at risk of language impairment have directly targeted parental language input (Romano and Windsor, 2020). This study found that parental modelling of deictic gestures, including pointing, showing, giving and reaching, increased the rate of deictic gesture use in low SES children (Romano and Windsor, 2020). Children involved in the intervention also displayed an increased rate of gesture and single word combinations. Though it is limited by its small sample size and cannot comment on longitudinal effects, this study is indicative that early interventions targeting parent communication can have direct impact on infants (Romano and Windsor, 2020). Researchers have suggested that future research should focus on identifying how early we are able to observe the potentially negative developmental effects caused by deprivation (Pace et al., 2017). Moreover, there is strong evidence suggesting that interventions targeted at families at risk for SES related disparities in child development have significant potential to mitigate the profound effects of SES on development (Cates et al., 2016).

In relation to resilience within the preterm population, it is worth mentioning that the relationship between prematurity and language development difficulties is not deterministic. While there is certainly an elevated risk within the preterm population due to neurological immaturity, infants born early are characterised by individual levels of resilience (Poehlmann-Tynan et al., 2015). Encouraging parents to read to their infants is known to promote healthy language development in children at risk for language delays (Hargrave and Sénéchal, 2000). Furthermore, the quality and quantity of a child’s linguistic environment (i.e., talking, interacting, reading) in the first three years of life are strongly associated with positive language and cognitive outcomes, in addition to later school readiness scores and academic performance (Zauche et al., 2016). Consequently, language interventions targeting the at risk preterm population have focused on parental language input. A nonrandomised intervention study found that a parent reading program in the NICU resulted in parents feeling an increased sense of control and increased intimacy with their infant (Lariviere and Rennick, 2011). Moreover, parents involved in the intervention were found to read more frequently to their infant post discharge than a historical control group that did not receive the intervention (Lariviere and Rennick, 2011). Given the complexity and intractability of both prematurity and SES, there is a strong argument to be made for interventions that target modifiable risk factors, such as parent language input.

2.6 Prematurity, SES and Langauge Summary

It is clear from the literature that there is an important intersection between prematurity, SES, and language development (Benavente-Fernández et al., 2020). A recent cohort study found that higher SES, here measured as maternal education, helped to mitigate the developmental impact of brain injury within a group of preterm neonates (Benavente-Fernández et al., 2019). The authors suggest that this result is indicative of opportunities to promote optimal outcomes within the preterm population, and the potential for higher SES to act as a mitigating and protective factor for cognitive outcomes (Benavente-Fernández et al., 2019). By improving our understanding of the directionality of the relationship between SES and prematurity, and the compounding effects of both, we can work to improve outcomes of infants born at risk. That said, there are significant methodological challenges that have made it difficult to relate SES and the development of infants born preterm.

2.6.1 Measurement Difficulties

I have shown that premature birth has significant developmental consequences, including in the language domain, but that these outcomes display significant inter-individual variability. One factor that challenges integration of previous findings and design of new studies is the many methodological issues, especially when also considering the effects of SES. Studies focusing on prematurity and language have been criticised for not comparing children of similar SES backgrounds (Foster-Cohen et al., 2007). As we have discussed, SES in and of itself can have significant consequences on language development, which makes it an important factor to control for when looking specifically at prematurity. Mothers of low SES are at an increased risk of having a baby born preterm, which often results in an imbalance of SES in prematurity studies (Cusson, 2003). Consequently, in studies that do not control for or consider SES, any resulting language differences in term and preterm children may not be a true reflection of a prematurity risk, but may in fact be a confounding and unmeasured risk of deprivation.

Additionally, although the cut off for using corrected gestational age is typically recognised as being at 24 months, there are inconsistencies as to the age corrections used in prematurity research; with some arguing for the use of chronological age while others argue for the merits of using corrected age (Cattani et al., 2010). Consequently, it is difficult to compare studies that use corrected age with those that use chronological age. There are also difficulties when comparing prematurity studies across different time points. Recent developments in neonatal care have resulted in improved survival for extremely preterm children (Blencowe et al., 2013). As a result, many older studies that look at preterm outcomes were not able to include these children that are now able to survive. These older studies are thus inclined to have participants of an older gestational age, compared to more recent studies which are able to include children born very or extremely preterm. Variability in research methodology, such as using birthweight vs. gestational age at birth as a measure of prematurity, also make it difficult to compare studies (Sansavini et al., 2010). There is significant variability among studies of language impairment and prematurity, which could be due to the various methodological issues discussed above. Nevertheless, there is significant evidence that children born prematurely are at an increased risk for language impairment that can persist across development. More studies, specifically longitudinal studies, are needed to better understand the language trajectory of infants who can be considered at risk of language impairment, either due to prematurity, deprivation or a compounded risk of both (Mangin et al., 2017).

2.7 Chapter summary

To summarise thus far, preterm birth is birth occurring before 37 weeks gestation and is associated with an increased risk of impairment in many neurodevelopmental outcomes, including a higher risk of later language impairment and delay. While prematurity itself is considered a risk factor for later language outcomes, it is not yet known if some other factor is mediating this relationship. Socioeconomic deprivation is also a known risk factor for later language difficulties. Moreover, mothers from a low socioeconomic background are at an increased likelihood of having a preterm birth. The mechanism through which socioeconomic status affects infant language isn't fully understood, but it is likely that this relationship is mediated by parent language, with children from a low SES being exposed to less parental speech and gesture, and are thus at a disadvantage in terms of their early linguistic environment. Thus, the goals of this thesis are to investigate the relationships between gestational age at birth, socioeconomic deprivation, and language exposure, operationalised as parental speech and gesture type and frequency during play in infancy. See figure 2-1 for a visual representation of the relationships under scrutiny in this thesis. While this is not a mathematical model, it serves as a visualisation of the proposed relationships between SES, prematurity, parent gesture and speech, and infant language outcomes. In chapter 2 I discussed the literature surrounding the relationship between prematurity and infant language and SES and infant language. I also briefly discussed some of the literature surrounding the effect of parent gesture and speech on infant language. In the following chapters I will examine these relationships more closely.

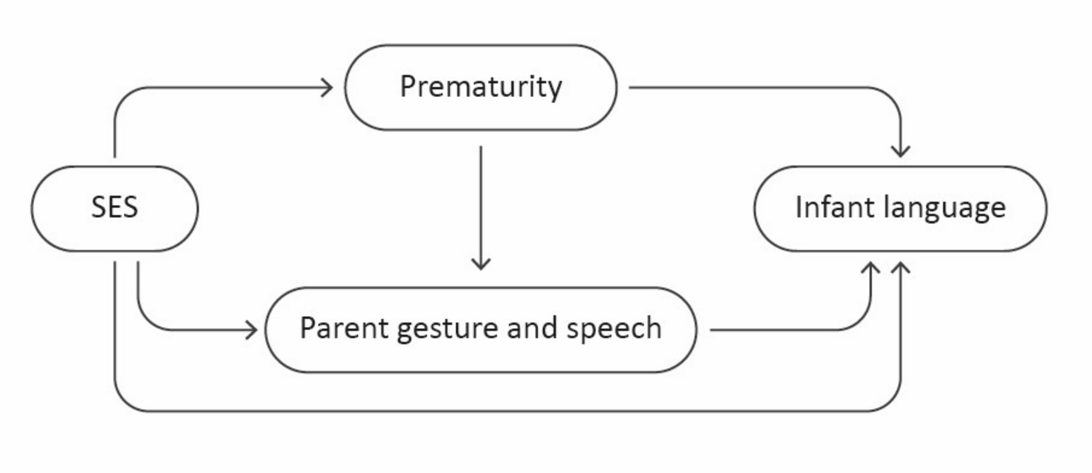

Figure 2-1 Proposed relationship between SES, prematurity, and language

2.8 Hypothesis and aims

The first aim of this thesis is to develop a novel coding scheme that allows for the accurate capturing of parental language and gesture when interacting with a non-verbal infant. Through the use of this novel coding scheme I am to increase our understanding of three things:

1. Does parental language and gesture differ as a function of prematurity?
2. Does parental language and gesture differ as a function of SES?
3. Are infant language outcomes at 24 months associated with familial SES, preterm birth, or parental language and gesture at 9 months?

In respect to the first research question, I hypothesized that there would not be differences in the use of vocabulary and gesture of parents of preterm vs. term infants. This prediction was due to the fact that our preterm sample had a similar SES to our term group and was not overly represented in a lower sociodemographic as is typical of infants born preterm. Thus, I predicted that parents of preterm infants would use similar language and gesture when communicating with their 9-month infant during parent child play than parents of term born infants. However, with regards to the second research question I predicted that there would be differences in the use of vocabulary and gesture of parents with different socioeconomic backgrounds. Specifically, I predicted that parents from a lower socioeconomic status would use less vocabulary and gesture when communicating with their infants. Finally, in reference to the third research question, I predicted that SES, gestational age at birth and parental communication at 9 months would be predictive of infant language outcomes at 24 months.

This thesis aims to explore the language and gesture used by parents when communicating with their 9-month-old infant. The studies presented in this thesis will investigate whether prematurity is associated with parental communication, by specifically examining the language and gesture of parents of term vs. preterm infants through the use of a novel coding scheme. Additionally, this thesis will explore if there are any SES related differences in parental communication, and whether parental communication, SES or prematurity have any predictive effect on infant language at 24 months. To date, there is little research examining the language and gestures used by parents when interacting with preverbal infants. Thus this thesis aims to explore a unique developmental stage through the use of a novel coding scheme designed to address the particular limitations of a dyadic interaction with a preverbal infant.

3 Methodology

3.1 Overview

As discussed in section 2.8, this thesis aims to understand how parental gesture and speech is influenced by markers of prematurity and socioeconomic risk, and how all of these in turn influence later infant language development. Here I describe the selected methodology including participant information, materials, and the procedure surrounding the video recorded parent child play session and subsequent later coding. To achieve the goals of this thesis it was necessary to create a novel coding scheme and this chapter therefore also describes the process of the creation of a coding scheme involving a parent and infant interlocutor. This project used observational video coding to analyse the level and diversity of parent language and gesture.

Video footage of parent and infant interaction during a 10-minute free play protocol, at 9-months or 9 months corrected gestational age (CGA), was used to capture parental vocabulary use and level of gesture production. Videos were coded for parental speech and gesture. Data created from the parental speech and gesture codes were combined with data made available for this thesis on prematurity (operationalised by gestational age) and markers of SES (operationalised by the Scottish Index of Multiple Deprivations). These data allow me to address my specific research questions pertaining to the relationships between prematurity, SES, and parental language output.

3.2 Study Context

This thesis was set within the Theirworld Edinburgh Birth Cohort (TEBC) (Boardman et al., 2020). The TEBC is an interdisciplinary and longitudinal study researching development of babies born early. The TEBC aims to understand the causes and implications of preterm birth, in the hopes of improving the outcome and lives of these babies and their families. The TEBC collects data on a wide range of outcome measures including medical, biological and social. See table 3-1 for a complete list of data collected within the TEBC. This thesis used a sub sample of the data collected from the Phase 2 cohort, at the 9-month and 24-month appointments, in addition to the demographic data collected at the neonatal time point.

There are approximately 400 infants (n=400), of which 300 are born preterm (n=300) involved in the TEBC Phase 2 cohort. This PhD included a subsample of 122 infants included in the TEBC Phase 2 cohort. Infants are recruited to the preterm group if they are born <32 completed weeks gestational age (GA). Term controls are born >36 weeks gestational age (GA). Infants with congenital anomalies, here defined as structural or functional anomalies (e.g. metabolic disorders) that occur during intrauterine life and can be identified prenatally, at birth or later in life, were excluded from the TEBC. These include anomalies such as heart defects, neural tube defects, and Down syndrome. Infants with a contraindication to MRI at 3 Tesla, such as those with an implanted medical device were also excluded from the TEBC. This was done as these congenital anomalies are known to be associated with poor developmental outcomes and consequently it would have been difficult to separate delays due to congenital anomalies from outcomes due to prematurity.

TEBC infants and their families are followed from birth until they are five years old, with data collection occurring following birth (neonatal time point), at 4.5 months, 9 months, 24 months, and 5 years. See table 3-1 for a complete list of all data collected by the TEBC at each time point.

3.3 Participants

Participants were recruited as part of the Theirworld Edinburgh Birth Cohort, Phase 2. All women who presented to the Simpson Centre for Reproductive Health with threatened preterm labour and for whom delivery was planned or expected at less than 32 completed weeks GA were assessed for eligibility. Additionally, women who attended the Simpson Centre for Reproductive Health for antenatal care or delivery at >36 weeks GA were assessed for eligibility.

3.3.1 Participants included in this study

Participants included in this thesis were recruited between September 2017 and January 2020. As mentioned previously, infants with congenital anomalies, such as malformations and infections, were excluded from the TEBC study. Additionally, participants were excluded from this thesis specifically if they communicated primarily in a language other than English.

Data were collected from a total of 122 infants, which was the total number of infants recruited into the TEBC Phase 2 at the time of this project. Data was collected on all eligible infants, with subsequent participants excluded from this particular thesis post data collection. A total of 22 infants were excluded from the final analysis. 17 were excluded as their parent child play involved a language other than English, while 2 were excluded from analysis due to a technical error involving the video camera. One was excluded as the infant was called back too early and thus fell outside of the included age range. 2 were excluded from analysis as their videos were used for the training of the second coder. See figure 3-1 for more information on participant inclusion. A total of 100 English speaking participants were included in the analyses reported in this thesis. Of this, 47 were preterm (mean gestational age of 29 weeks, range of 24-31 weeks) and 53 were term born (mean gestational age of 39 weeks, range of 36-42 weeks). 58 infants were male and 42 infants were female.

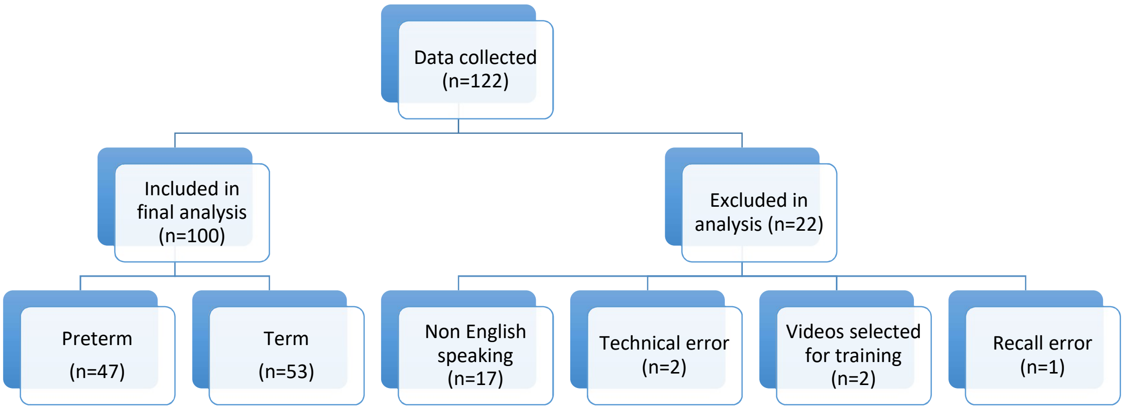

Figure 3-1. Participant inclusion numbers

3.4 Materials

As this thesis was positioned within the larger TEBC study, significant volumes of data were collected but not directly used for the purpose of this thesis (Boardman et al., 2020). All data collected during the TEBC are outlined in table 3-1. Data included in this thesis will be outlined in more detail below.

Antenatal	Maternal education -Parental education -Scottish Index of Multiple Deprivation -Medical history and exposures
Birth	-Medical history and exposures -Anthropometry -Placenta sampling -Cord blood -Blood sample -Blood spot
Neonatal	-Blood spot -Blood sample -Saliva sample -Nasal secretions -Stool sample -Anthropometry -ROP assessment

	-National Adult Reading Test -Optical coherence tomography -MRI -Demographics -Infant Behaviour Questionnaire Revised short form
4.5 months	Demographics (maternal education, breastfeeding, activities) -IBQ revised short form -WHO QOL -Nasal secretions
9 months	-Saliva -Anthropometry -Nasal secretions -Eye tracking -Visual Acuity -Still face -Parent child interaction -Infant Behaviour Questionnaire Revised short form -Vineland adaptive behaviour scales: --Comprehensive interview form -WHO QOL -Sleep and Settle -MacArthur Communicative Development Inventory (Words and gestures)
24 months	Anthropometry -Nasal secretions -Eye tracking -Parent child interaction -Following instructions -Early Childhood Behaviour Questionnaire short form -Quantitative Checklist for Autism in Toddlers -Behviour Rating Inventory for Executive Function, Pre-school -WHO QOL -Vineland adaptive behaviour scales: comprehensive parent rating form -MacArthur communicative development inventory (words and sentences)
5 years	-Saliva -Nasal secretions -Anthropometry -Blood pressure -Parent child interaction -Following instructions -Mullen Scales of Early learning -Eye tracking -Children’s communication checklist Behaviour rating inventory for executive function -WHO QOL

Table 3-1 TEBC Materials

3.4.1 Materials: Neonates

Information collected during the neonatal data collection point that are included in this thesis include maternal education, paternal education and SIMD2016.

Maternal and paternal education were collected via a questionnaire directly administered to the parents by a research nurse. Parents were asked what their final educational qualification was and offered 7 response options; None; 1-4 GCSE passes at GSE; GCSE, O level; >5 passes at CSE, GCSE, O level; A levels or Highers or equivalent; College qualification (eg. NC, HND, HNC, etc); University; Postgraduate degree; N/A.

As discussed in section 1.3.1, information on socioeconomic status was reported using the Scottish Index of Multiple Deprivation 2016 (SIMD). The SIMD is a multiple measure tool used by the Scottish government to rank small areas, referred to as data zones, from most deprived to least deprived (Scottish Government, 2016). The SIMD 2016 splits Scotland into 6, 976 data zones all with similar population sizes. These data zones are then examined for multiple indicators of deprivation, including factors such as travel times to GP, school pupil attendance, and unemployment rates. These indicators of deprivation are grouped into seven domains (employment, income, crime, housing, health, education, access), which are then grouped into one SIMD. This results in each data zone in Scotland being ranked from 1 (most deprived) to 6,976 (least deprived), (Scottish Government, 2016). SIMD scores were therefore extracted from the Scottish Government rankings, based on the participants' postal code. Participants in this study had a range of SIMD scores. See table 3-2 for participant demographic information.

Mesure		Mean	Standard Deviation	Minimum	Maximum	Skew	Kurtosis
SIMD 2016 rank	Preterm (n=43)	4180	2036	137	6929	-.30	-1.14
	Term (n=49)	4638	1914	727	6936	-.60	-1.01
Maternal level of education	Preterm (n=43)	4.49	1.40	1	6	-.90	.24
	Term (n=49)	4.88	1.24	1	6	-1.83	3.26
WHO-QOL scores	Preterm (n=38)	8.18	1.29	5	10	-.52	-.16
	Term (n=50)	8.60	1.44	4	10	-1.12	.88
SSQ scores	Preterm (n=39)	16.36	6.31	8	37	1.08	1.55
	Term (n=53)	16.91	5.40	9	29	.56	-.47
Birthweight (grams)	Preterm (n=47)	1315	354	600	1950	-.13	-.92
	Term (n=53)	3556	466	2556	4580	0.23	-.19
Gestational age/weeks	Preterm (n=47)	29.13	1.66	24	31	-.92	.51
	Term (n=53)	39.28	1.23	36	42	-.25	.31

Table 3-2 Participant Demographics

Information on markers of prematurity including birth weight (grams) and gestational age were collected by a member of the research team at the neonatal time point. See table 3-2 for more information on prematurity demographics. Gestational age is a measure of the age of a pregnancy, based on the first trimester ultrasound. Information regarding gestational ages is recorded by an NHS provider using Maternity Trak. Birthweight was recorded by an NHS provider at birth and is measured in grams.

3.4.2 Materials: 9 months

Materials used in this thesis from the 9-month data collection point include the WHO QOL, Sleep and Settle Scale “Bother” Score, and the parent-child interaction.

The WHOQOL-BREF is a short form self-report questionnaire that serves as a quality of life assessment (Webster et al., 2010). It is divided into four domains; physical health, psychological, social relationships, and environment. The WHOQOL-BREF was included in the questionnaires sent to parents ahead of their 9-month appointment. The completed questionnaires were scored after the completion of the 9-month appointment by a member of the research team. The WHOQOL-BREF is only completed by mothers. Although the WHOQOL-BREF is completed by mothers at multiple time points during their participation in the TEBC, including at 4.5 months and 24 months, only the 9 month WHOQOL-BREF was included in the analysis of this thesis. As the main focus of this thesis centred on parental language input at 9 months, the WHOQOL-BREF collected at 9 months was determined to be the most relevant as this was also the time point that parental language input was being collected, in the form of the parent-child interaction.

The Sleep and Settle questionnaire, which from now will be referred to as the SSQ, is a questionnaire that provides information on an infant’s sleep and settling behaviour as well as offers insights into the parents perspective regarding their infants sleep and settling behaviour (Matthey, 2001). It allows for the measurement of both day time and night time sleeping behaviours as well as offers insight into the parental perceptions of their infants sleep and their ability to manage their infant’s sleeping. The “Bother” scale is a specific parent report measure that captures how parents feel about their abilities to settle their infant.

The parent-child interaction is a videotaped semi structured free play session between parents and infants. Parents are instructed to play as they would normally at home with their infant and are given a selection of toys. More detail on the parent-child interaction can be found in the procedures section of this chapter. See figure 3-2 for an image of the toys available for use during the parent-child interaction.

Figure 3-2 Toys used in parent child interaction

3.4.3 Materials: 24 months

Materials used in this thesis from the 24-month data collection point include the MacArthur Bates Communicative Development inventory (words and sentences) and the communication domain scores from the Vineland Adaptive Behaviour Scales. The MacArthur Bates Communicative Development Inventory is a parent report instrument designed to measure early language abilities including vocabulary comprehension, vocabulary production, gestures and early grammar (Fenson, 2002).More information on the MacArthur Bates Communicative Development Inventory is discussed in detail in chapter 6 of this thesis. The Vineland Adaptive Behaviour Scale is a parent report standardized assessment tool that measures adaptive behaviour and is used to support the diagnosis of development delays (Pepperdine and McCrimmon, 2018). More information on the Vineland Adaptive Behaviour Scale can be found in chapter 6 of this thesis.

3.5 Procedure

I will begin by outlining the wider TEBC procedure before elaborating on the procedure for the 9-month and 24-month appointments, as these appointments were the primary source of data for this thesis.

3.5.1 TEBC procedure

Following the collection of informed consent, antenatal data is collected from the parents. This includes a measure of SES, the SIMD (Scottish index of multiple deprivations), and medical and demographic information. A full list of data collected at this point can be found in table 3-1. Following this, information is collected at birth including record data, questionnaire data and tissue sampling. Neonatal data are then collected including tissue sampling, stool sampling, observational data, questionnaire data, and MRI. See table 3-1 for a complete list of samples collected. At this stage participants are handed over to the follow up team who will collect data at the 4.5 months to 5 year stages. Data collected at the 4.5-month time point includes questionnaires, administered either by post, online or phone interview and tissue sampling. This thesis is focused on data collected at the 9-month and 24-month time points.

3.5.2 Procedure: 9 months

At least one month prior to an infant turning 9 months, or 9 months corrected age, they were contacted by a member of the follow up team to arrange their 9-month appointment. The optimal window for data collection was two weeks either side of the 9-month date. Corrected age was used for all preterm analysis, as is standard practice in research involving preterm infants (Johnson & Marlow, 2006). Approximately two weeks prior to their visit, parents were asked to complete a series of questionnaires. Questionnaires included the EBC Record form, IBQ short form, McArthur Communicative Development Inventories-Words and Gestures, WHOQOL-BREF, and the Sleep and Settle Questionnaire total form. Any changes in circumstance were noted in the EBC record form, this included any changes in address, which would result in changes in SIMD.

Data for this study was collected at Kennedy Tower in Edinburgh, the site of the University of Edinburgh's Department of Psychiatry. All data collection was completed in a small testing room designated for the Theirworld Edinburgh Birth Cohort, excluding biological measurements which were undertaken in a distinct examination room located in the same building. Data collection was completed by a team of researchers working on the Theirworld Edinburgh Birth Cohort. Biological samples described in the "biological sampling" section below, were collected by NHS Research Nurses.

Parents and infants were met in the lobby of the building and escorted to the lab by a member of a research team. All tasks to be completed during the appointment were outlined to the parents. Parents were given the opportunity to pose any questions they may have had regarding the appointment, and assured that they could stop participation at any point during the appointment. Parents were present for all aspects of data collection. The author of this thesis was unable to be blinded to preterm or term born status as there were too many physical markers indicating the status of the infant. Additionally, parents would often mention their experience in the neonatal intensive care unit during the 9-month appointment, thus resulting in an immediate unblinding.

3.5.2.1 Biological sampling

Parents were introduced to the research nurse before the collection of any biological measurements. Biological samples collected at each appointment included weight, height, occipito-frontal circumference, skin fold thickness, saliva sample (DNA), saliva sample (cortisol). A subsample of participants also underwent SAM sampling-nasosorption for cathelicidin analysis and nasopharangeal swab for respiratory microbiota analysis.

3.5.2.2 Parent-child interaction

Following the biological sampling, parents and infants were brought back into the lab for the parent-child interaction. Parent and infant dyads were filmed during a ten-minute free play protocol. During parent child play, infants and parents were presented with a series of toys; a small plastic car, a sound producing ball, blocks, a doll with a removable hat, blanket and bottle, and a fabric book. See figure 3-2 for an image of the toys included. All parent and infant pairs had access to the same set of toys, which are a similar selection, in terms of their affordances, to those used in other infant studies (see Iverson et al 2008, Goldin-Meadow et al 2007). Toys were placed on a colourful mat in the centre of the room and parents were advised to remain on the mat as much as possible as they would be video recorded. A video camera was set up in the corner of the room, and parents were aware that they would be recorded.

Parents were instructed to play with their infants as they would normally do at home. In cases of bilingual or multilingual speakers, parents were advised to play in the language that they would typically use in a home environment. As mentioned previously, all play sessions that involved more than 10 instances of a language other than English were excluded from this study. Researchers left the room during the parent child play.

3.5.2.3 Visual acuity

Visual acuity of all participants was assessed using Keeler Acuity Cards, a preferential looking task that uses a series of grating test stimuli (McDonald et al., 1985). Keeler cards are commonly used to measure visual acuity during infancy (Jones et al., 2014).

3.5.2.4 Still face

Infants participated in the still face paradigm for 10 minutes. Parents were seated across from their infants and instructed to play with their infants as they would normally. Infants were securely seated in a high chair. After two minutes of play parents were instructed to ignore their infants, look away from them and adopt a neutral facial expression. This still face period was for two minutes, after which they would go back to playing. Parents would alternate between play and still face for 2 minutes each for a total of 10 minutes. For a sub sample of infants, additional saliva sampling for cortisol analysis was collected prior to the still face, and at 20 and 30 minute intervals following the still face.

3.5.2.5 Eye tracking

Infants were presented with a 20-minute eye tracking battery. Tasks included in the eye tracker assessment included; measures of social attention, attention switching and disengagement, sustained attention and visual search. Parents were instructed to hold the infant on their lap throughout the eye tracking assessment, and breaks were provided as needed.

3.5.2.6 Questionnaires

In addition to the questionnaires completed by the parents prior to the visit they were also interviewed using the Vineland Adaptive Behaviour scales: v3, comprehensive parent interview form with prompts (Pepperdine and McCrimmon, 2018).

3.5.3 Procedure: 24 months

As with the 9 month appointments, parents were contacted at least one month prior to turning 24 months, or 24 months corrected. The window for data collection was two weeks either side of the 24-month date. Corrected age was used for all preterm analysis, as is standard practice in research involving preterm infants (Johnson & Marlow, 2006). Approximately two weeks prior to their visit, parents were asked to complete a series of questionnaires. Questionnaires included the EBC Record form, McArthur Communicative Development Inventories-Words and Gestures, WHOQOL-BREF, Early Childhood Behaviour Questionnaire short form, Quantitative Checklist for Autism in Toddlers, Behaviour Rating Inventory for Executive Function (preschool), Vineland adaptive behaviour scales: comprehensive parent rating form (Fenson, 2002; Pepperdine and McCrimmon, 2018; Webster et al., 2010).

As before, data at the 24-month appointment was collected at Kennedy Tower in Edinburgh, the site of the University of Edinburgh’s Department of Psychiatry. Parents were present for all aspects of data collection. All data collection was completed in a small testing room designated for the Theirworld Edinburgh Birth Cohort, excluding biological measurements which were undertaken in a distinct examination room located in the same building. Data collection was completed by a team of researchers working on the Theirworld Edinburgh Birth Cohort. Biological samples described in below were collected by NHS Research Nurses.

3.5.3.1 Biological sampling

Parents were introduced to the research nurse before the collection of any biological measurements. Biological samples collected at each appointment included weight, height, skin fold thickness, and occipito-frontal circumference. A subsample of participants also underwent SAM sampling-nasosorption for cathelicidin analysis and nasopharangeal swab for respiratory microbiota analysis.

3.5.3.2 Parent-child interaction

Following the biological sampling, parents and children were brought back into the lab for the parent-child interaction. Parent and child dyads were filmed during a ten-minute free play protocol, which allows for the capture of spontaneous parental speech and gesture during an interaction between parents and preverbal infants. During parent child play, children and parents were presented with a series of toys; a book, a toy phone, a doll with a removable hat, blanket, sound producing drum set, and building blocks. All parent and child pairs had access to the same set of toys. As before, toys were placed on a colourful mat in the centre of the room and parents were advised to remain on the mat as much as possible as they would be video recorded. A video camera was set up in the corner of the room, and mothers were aware that they would be recorded.

Following the protocol from the 9-month appointment, parents were instructed to play with their child as they would normally do at home. In cases of bilingual or multilingual speakers, parents were advised to play in the language that they would typically use in a home environment. Researchers left the room during the parent child play. Video footage was scored on a secure University of Edinburgh computer.

3.5.3.3 Eye tracking

Children were presented with a 20-minute eye tracking battery. Tasks included in the eye tracker assessment included; measures of social attention, attention switching and disengagement, sustained attention and visual search. Parents were instructed to hold their child on their lap throughout the eye tracking assessment, and breaks were provided as needed.

3.5.3.4 Following Instructions

Children were presented with a series of items and asked to follow a series of instructions. Items included a yellow plate, green plate, blue plate, yellow box, green box, blue box, yellow spoon, green spoon, blue spoon, yellow pencil, green pencil, and a blue pencil. These instructions became increasingly more complicated and involved one or two step commands. For example, “touch the green spoon” or “pick up the yellow box and the blue plate”. The task was stopped after three consecutive incorrect trials.

3.5.4 Ethics and consent

Ethical approval was obtained from the National Research Ethics Service (NRES), South East Scotland Research Ethics Committee, and NHS Lothian Research and Development (Boardman et al., 2020). This study was conducted according to the principals of the Declaration of Helsinki, and adhered to guidelines laid out by the British Psychological Society. This study was conducted in accordance with the principles of the International Conference on Harmonisation Tripartite Guideline for Good Clinical Practice (ICH GCP). The author of this thesis undertook GCP training and maintained certification over the course of the study.

Consent from parents was sought from each participant after they received a full verbal explanation of the study, offered an information leaflet and allowed time for consideration. Signed participant consent was obtained at two stages: the perinatal and neonatal sampling and assessment stage, and the assessments post-discharge to 5 years. Consent was acquired both from the parents to participate and then from the parents to consent for the participation of their infant.

3.6 Coding Scheme

Video coding was chosen as an appropriate method to capture naturalistic gestures and speech of parents when interacting with their infants. Parents were unaware of the nature of the behaviours being coded, thereby minimising the impact on their behaviour. This method is commonly used in gesture studies and permits the capture of naturalistic interaction between parents and infants (Fusaro et al., 2014).

Additionally, using video coding permitted researchers the opportunity to re-watch and revisit footage which allowed for accuracy and precision in coding.

Although I originally planned on using typical gesture classifications of beat, iconic, and deictic, initial viewing of the first two videos indicated that traditional gesture categories would not be sufficient in adequately capturing the nonverbal behaviour of parents in the sample (McNeill, 1992). As the interlocutor is 9 months old, the way in which parents are gesturing is very different to how they would gesture when speaking with an older and more verbal conversational partner. For example, Schmidt (1996) found that mothers of 10-month-old infants used more displaying gestures and less pointing and naming gestures than mothers of older toddlers. Schmidt and Lawson (2002) argue that parents use what they call “caregiver attention-focusing behaviours”, which they define as gestures and/or speech that are used by parents to direct infant focus. While the traditional view of gestures argues that gestures function primarily to convey important semantic information, this wider view suggests that any gesture made by caregivers may also serve to direct infant attention. Thus, while caregiver gestures may not appear to be directly offering semantic information, it can be argued that they are still serving as important communicative input for the infant.

It has also been argued that mothers alter their gestures when communicating uniquely with children (O’Neill et al, 2005). It has been found that they gesture less and produce simpler gestures overall compared to when they are communicating with adults (Bekken, 1989; Shatz, 1982). From this, Iverson and colleagues (1999) suggested that mothers are employing a kind of “gestural motherese”, whereby gestures are serving to direct attention and reinforce speech, rather than provide new information not contained semantically. In their study, Iverson and colleagues argued that deictic gestures display “communicative intent” through the directing of infant attention. They coded showing, indicating and pointing as deictic gestures, which included instances of interaction with objects. They also included emphatic gestures, which were defined as non-representational gestures that do not direct attention to a specific referent, though these gestures were found to be less common than deictic gestures (Iverson et al 1999).

As mentioned, initial viewing of the first two videos indicated that parents were not using traditional gestures of iconic, beat, and deictic and it became clear that traditional gesture classifications would not adequately describe this particular sample. From this it was decided that a novel coding scheme would be created in order to better capture parental movements when communicating with their infants.

This novel coding scheme was designed to capture the gestural movements made by parents, specifically when they are communicating with their infants. The aim was to measure more accurately the kinds of movements made by parents in a situation where their interlocutor was a preverbal infant. The coding scheme was developed to be representative of the kinds of movements made by parents. Additionally, it was designed to be as objective as possible, with each category of gesture being mutually exclusive in that any movement would only be able to be coded within one category. Taking into consideration the time commitment of video coding, the coding scheme was limited to five categories which was felt to be sufficient to adequately capture the richness of the movement.

3.6.1 Coding scheme development- gesture

The first two videos that were used for exploratory viewing were once again re-watched with a specific focus on how the parents were moving their hands. These videos were subsequently excluded from analysis and used for training the second coder. From these two videos, it became clear that parents spend the majority of their time interacting physically with their environment, in this case the toys, or with their infant. This is in contrast to how adults are typically found to gesture whereby gestures are used to convey information or place emphasis on particular elements of speech (McNeill, 2008). Following from Iverson et al (1999), we decided to eschew typical gesture classifications and broaden our idea of what counts as gesture. Similarly to Schmidt and Lawson (2002), we emphasized how parents were often using their movements to direct infant attention. Our proposed gesture classifications include giving, manipulating infant, manipulating object, pointing, and other. This allowed us to capture a more accurate representation of the behaviours shown by parents when interacting with their infants during a parent child play, and was assumed to be more indicative of the kind of early gesture that infants are exposed to from their parents.

3.6.2 Coding scheme development- speech

During the initial coding of the first two videos, it also became apparent that any potential concerns involved in the transcription of speech would be in relation to the use of motherese and Scottish colloquialisms. Motherese is the mother-child code seen across cultures during verbal interactions between mothers and infants (Furrow et al., 1979). It is described as being higher in pitch, contains short utterances, simpler language and multiple instances of repetition (Nelson et al., 1989). The potential difficulty in coding motherese is that it often contains maternal babbling or repetition of syllables in a non-word like way. From this, I decided upon a protocol that would be followed in all observed instances of motherese, to ensure consistency across participants and coders.

Toda, Fogel and Kawai argued that maternal speech to preverbal infants serves to provide input for later language acquisition and socialization for "culturally appropriate communication" (Toda et al., 1990). Sung et al included words not directly directed to the infant in their analyses, as they argued that non-directed speech can still serve as a language stimulus (Sung et al., 2013). Additionally, they also included maternal babbling. Sung and colleagues argued that non-directed speech can still serve as a language stimulus, and thus they coded all utterances identifiable as words, even if the language output wasn't directly focused on the infant (Sung et al., 2013).

Following Sung et al, it was decided that all parental speech in our samples would be coded, even when not identified as addressing the infants directly (Sung et al., 2013). Similarly, we did not include any non-syllabic noises such as hissing or shushing but did include transliterated sounds and vocalised exhales, for example “Ah” or “Ah ba ba”. Additionally, we did not code laughter, or mouth and lip manipulations that are not vocalised, such as blowing. Finally, we did not include coughing or vocalised inhales in our coding, as coughing is involuntary and vocalised inhales are too inconsistent to be considered a reliably coded variable. See table 3-4 for a comprehensive list of what was and was not included in language coding.

Using protocols typically followed in the case of code switching bilingual French/English speakers, any Scots words or common Scottish colloquialisms were coded as word types (Genesee et al., 1996). As per Genesee, Nicoladis and Paradis, utterances that deviated from typical pronunciation were coded phonetically (Genesee et al., 1995). A standardized list of commonly used Scots words and colloquialisms was provided to the second coder, to ensure a standardized spelling across codes. Only parent child play sessions with English speaking parents were included in analysis. Any videos that involved instances with a language other than English were excluded, with the exception of videos that had fewer than 10 instances of a language other than English. Those videos were included, and the non-English text was coded phonetically.

Following this, the original two videos were coded using the new coding scheme. Unlike the first viewing of the videos, where no standard gestures were observed, the new coding scheme produced significantly more codes and multiple instances of each code category in the new scheme were observed. Additionally, the coding scheme was applied to the transcriptions without issue. From this it was decided to apply the new novel coding scheme to an additional 10 videos. Following the completion of the ten videos the coding scheme was reviewed, found to be effective, and therefore applied to all remaining videos. The original two videos were not included in further analysis and were instead used for training purposes for the second coder.

3.6.3 Final coding scheme

The final coding scheme included the following categories: manipulating infant, manipulating object, pointing, giving, and other. More information on each category of code can be found in table 3-3 and visual examples of each code, with the exception of the "other" code, can be found in figure 3-3.

	
Giving	Manipulating infant
	
Manipulating object	Pointing

Figure 3-3 Examples of gesture categories

Code	Description
Giving	Defined as any instance of the parent holding an object out with the intention of giving it to the infant. This also included instances of the parent holding out hands/presenting them to the infant to take. Rolling a ball towards an infant was not considered as giving but was instead classified as a manipulation of object. In instances where a parent was holding an object and the infant took it from their hands, with or without any obvious parental intention of directly giving, this was also coded as giving.
Manipulating infant	Defined as any instance where a parent physically interacts directly with the infant. This includes forms of touching without movement of the infant, such as putting a hand on the infant's back for support or brushing an infant's hair. Any physical limitations of infants, such as needing extra support to sit upright, were noted in the case of potential outliers. When parents would lift or carry infants this was also coded as a manipulation of the infant, with the code being separated by any change in movement or intention. For example, a code would start when a parent lifted the infant in the air, and end when the movement changed to pulling them closer to their body.
Manipulating object	Defined as any instance of the parent moving or manipulating an object. This code included any time the parent touched a toy or the play mat. In instances where the parent touched a personal item, such as a tissue or pacifier these were coded as manipulating object but it was noted that the object was external.
Pointing	Defined as any gesture used to indicate towards a particular object/location of interest through the use of a single finger extended outwards. While pointing gestures are typically defined as an extension of the index finger, given that parents of 9 month olds are often holding other things during interactions, this has been expanded to include any single finger extension. Initial viewings of the video indicated that this was a necessary expansion, as parents will often use their thumbs to point if their index finger is occupied with another object. For example, when holding the ball or book, parents will often use their thumb to point while their index finger is involved in the manipulation or holding of the object. This is similar to the parameters of the pointing gesture as defined by Iverson et al (1999).

Other	Defined as any gesture that does not fit into the classification codes detailed previously. This could include instances of classic iconic gesture, such as manipulating fingers to indicate a heart shape or separating hands with palms facing inwards to indicate the size of something. Clapping, waving and classic beat gestures, the random hand and arm movements made when speaking to add emphasis onto certain words, were also coded as other. Every gesture coded as other was briefly described directly in ELAN.

Table 3-3 Final gesture coding scheme

3.7 Coding procedure

Each parent child play video was uploaded onto a secure University of Edinburgh server. Similarly to other gesture studies, ELAN software (EUDICO Linguistic Annotator), a free open sourced language software was used for coding the parent child play (Lausberg and Sloetjes, 2009; Wittenburg et al., 2006). ELAN was chosen as it allows an unlimited number of annotations to be added to videos, with multiple possible tiers allowing for several codes to be produced simultaneously. ELAN also allows for the export of files in various modalities including CHAT and tab-delimited text files, which were used for later language analysis with the CLAN (Computerized Language Analysis) program (MacWhinney, 2018; Wittenburg et al., 2006).

10 minutes of each video was coded for both language and gesture. 91 out of 100 videos were coded from 0:05-10:05. 9 videos were coded from 0:10 to 10:10. This was due to delays in the play commencing, such as the researcher taking longer to exit the room. Each start and stop time of individual videos was noted. Videos were watched twice, the first viewing focusing on language coding and the second focusing on gesture coding. The order in which videos were coded remained consistent throughout this project. This was done as transcriptions often provided important information that facilitated gesture coding. For example, parents would sometimes use a finger other than the typical pointer figure when pointing, as they were often holding an object. By coding transcriptions first, it allowed additional

information to be included when coding the gesture. For example, if parents extended a finger and the coder was unable to decide if it should be classified as a point, access to the transcription that may include a declaration, for example "it's a blue fox" facilitated the gesture coding process. Language data for all participants were stored on a secure University of Edinburgh computer. Raw data was stored in a master data excel sheet while individual transcriptions were stored on a University server.

3.7.1 Language coding procedure

Videos were first transcribed for parental speech, noting each time-stamped utterance. Speech was divided into utterances using similar criteria to that used by Iverson et al, whereby utterances are divided by a change in conversational turn, change in intonation or a silence for at least 10 milliseconds (Iverson et al., 1999). Utterances unidentifiable as words were coded phonetically. Similarly, any parts of an utterance that deviated from typical pronunciation were coded phonetically (Genesee et al., 1995). Utterances were marked as "XXX" if indecipherable, as suggested by the CLAN software protocol (MacWhinney, 2018).

Non-words coded phonetically were separately marked down and labelled, to make certain that the spelling of these non-words remained consistent, ensuring that they were coded as similar word types in the case of any repetition. For example, a non-word such as "yeow" could be coded in a variety of different ways despite an identical pronunciation throughout the video. As such, the first instance any non-word, such as "yeow" was noted on a separate document, serving as an informal glossary which indicated the spelling, and time point, to ensure that any repetition of said word would consequently be coded in a consistent way. The creation of this glossary for each video ensured that non-words were coded as consistently as possible. See table 3.4 for a complete list of what was included in the language coding procedure.

Once coding of language was complete, the transcription of each video was exported into a CHAT de-liminated text file. Transcriptions were then analysed using

CLAN (Computerized Language Analysis) (MacWhinney, 2018). CLAN was chosen as it is a free open sourced language software that is capable of performing a significant number of analysis on large volumes of transcript data.

Using the [freq] analysis command in CLAN, each transcription was analysed to produce a count of word types, word tokens, and type/token ratio. Word type is the number of different words spoken by the mother, while word tokens is the total number of words used during the interaction. For example, the sentence "I went to the shop and then the bank" contains 8 word types and 9 word tokens. Type/token ratio is the number of word types divided by the number of word tokens, with a high type/token ratio indiciating a high degree of lexical variation. Following this the [mlu] analysis command was run in CLAN, which produced a total number of utterances and mean length utterance (MLU).

What WAS included	**Example**	**What WAS NOT included**
Words	Ball	Non-syllabic noises
Utterances identifiable as words	Vroom	Laughter
Transliterated sounds (spet phonetically	Woosh	Mouth and lip manipulations (eg. Blowing)
Vocalised exhales	Mhmm	Vocalised inhales

Table 3-4 Language exclusions

3.7.2 Gesture coding procedure

Following the creation of a full transcription, videos watched a second time to code for gesture. Using the coding scheme outlined above, each movement made by the parent was coded as either manipulating infant, manipulating object, pointing, giving, or other. Each movement made by the parent was coded for duration of movement, handedness, and type of movement. The parameters of each gesture were defined by either a pause in the movement or an obvious change in the shape or trajectory of the movement (see Kong et al, 2016). Gestures were coded globally, meaning that the whole gesture was coded as a unit, rather than separating the individual flexion and extensions of the hand or arm. For the purpose of coding, gestures can be thought of similarly to vocal utterances, as they are also defined by moments of physical rest or a change in intention. An example of a change in intention would be the moment of switching between pushing a toy car along the ground to pushing the car along the leg of the infant. Any proprioception or personal manipulations, such as covering mouth when coughing or fixing hair, were not coded. For a full list of what was not coded see table 3-5.

What WAS included	**Example**	**What WAS NOT included**
Manipulating object	Parent picks up doll	Parent touches own face
Manipulating infant	Parent picks up infant	Parent adjusts own clothing
Pointing	Parent points to doll	Parent shifts own body
Giving	Parent hands doll to infant	Parent stretches
Other	Parent claps hands	

Table 3-5 Gesture exclusions

After coding, gesture data was exported into Excel for the production of gesture counts. Each video produced a list of every gesture coded during the 10 minutes. Using the [countif] function in excel, each code was counted to produce a total count of gesture within each gesture category.

3.7.3 Reliability

A second blind coder, was trained by the primary coder, and then independently rated 10% of the videos, to ensure inter-rater reliability. Every 10th video was selected for secondary coding. Only primary coder scores were included in the analysis. All codes produced during reliability checks were excluded from analysis and only used to verify the reliability of the novel coding scheme. Agreement rate between coders for the total number of gestural events was 94%, and had a Cohen's kappa of .745 for the classification of gestures. Agreement between coders on language measures was an average of 98% (range 0.983-0.998 ICC).

3.7.4 Second Coder Training

The original two videos used during the development of the novel coding scheme were used for training and discussion. The first video was watched and coded together, discussing the process throughout the coding procedure. The following video was watched together and coded by the second coder with the original coder present for discussions as needed. The second coder ratings collected during their training period were discarded and not used in any subsequent analysis. The second coder was considered a competent and reliable coder after two videos coded independently had a less than 10% error, in terms of the number of codes within each category of gesture and the number of word tokens. The second coder was deemed a competent and reliable coder after the first two videos coded independently. As both videos coded independently had a percentage agreement of above 90% they were included in the 10% of videos coded by the second coder.

3.8 Methodological limitations

While this coding scheme benefits from a minimization of subjective interpretations of gesture categories, it is not without its limitations. This coding scheme does not allow for the inclusion of parent-child interactions that occur in a language other than English. Moreover, as the word type count is done via CLAN, any spelling mistakes or diversity in the spelling of non-words will result in an incorrect increase of word types. To address this, as mentioned previously, all non-words, Scots words and colloquialisms were spelled consistently within each video, through the use of a glossary created during the coding procedure.

As participation in the TEBC is voluntary, this study does also run the risk of a selection bias. Typically, preterm infants are disproportionately represented in a lower SES demographic, however, our sample of preterm infants did not have significantly lower SES than our term infant sample. More information on the demographics of the sample used in this thesis can be found in chapters 4, 5, and 6. As parents were aware that they were being videotaped, there is also a risk of non-naturalistic behaviours and play. In an attempt to minimize this, parents were recorded during the parent child play after spending some initial time in the space with the researchers, to make them feel as comfortable as possible in the lab setting. As infants are undergoing a significant amount of data collection that is not included in this analysis, the risk of fatigue is evident. To address this, the parent child play was done towards the beginning of each appointment. A more detailed review of the coding scheme limitations will be presented in the discussion, chapter 7, of this thesis.

3.9 Summary

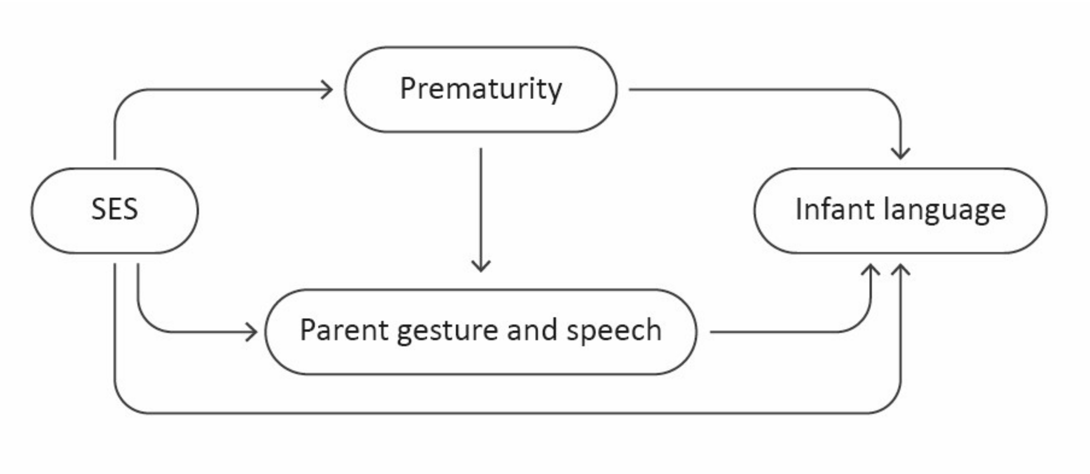

Figure 3-4 Relationships of interest

As discussed in this chapter, SIMD 16 rank will be used to capture SES, gestational age will be used to capture prematurity, and parent communication will be assessed via novel gesture codes, MLU, word types and word tokens.

Gesture studies and prematurity studies are both often limited by small sample sizes (Iverson et al., 1994). This thesis examines a large number of parent-infant dyads (n=100), to explore the specific language and gesture used by parents of both preterm and term born infants, from both high and low SES backgrounds. A novel coding scheme was developed to adequately address the unique interaction that occurs between a parent and infant, and the specific gestures used when communicating with a nonverbal interlocutor.

47 parent-preterm infant dyads and 53 parent-term infant dyads from the Theirworld Edinburgh Birth Cohort were examined in this thesis. Parents were video recorded for 10 minutes interacting with their child during play, and videos were subsequently coded for parental language and gesture count. The first study in this thesis investigates the gesture and vocabulary used by parents of preterm and term born infants. This study elaborates on the novel coding scheme developed for this thesis, and examines whether there are differences in the communication styles of parents of term born vs. preterm infants. The following study uses the same set of video recorded parent child play sessions, and examines any differences in communication styles that result from differences in SES, as measured by the Scottish index of multiple deprivations. Finally, the third study presented in this thesis examines approximately half of the sample at 24 months, using language scores collected from the MacArthur Bates Communicative Development Inventories Words and Sentences and the communication scales from the Vineland Adaptive Behaviour Scales.

For all studies, normality was assessed through descriptive statistics, visual inspection of histograms and Q-Q plots, and the examination of skew and kurtosis values. Baseline statistics were reported, and independent t-tests were used to test for significant differences between groups. Pearson's correlation was used to examine continuous relations between language and gesture variables, and gestational age at birth and SES. Finally, regression analysis was used to explore any predictive relationships between variables of interest. All analysis was done using SPSS 24.

4 Effects of prematurity on parental communication during parent child play

4.1 Overview

In chapters 1 and 2, I demonstrated that there is significant evidence that infants born preterm are at an increased risk for later language delay and impairment (Sansavini et al., 2010). While the exact mechanism through which this relationship operates is unknown, certain theories have been presented. Disruptions to early parent-child interaction on the NICU and beyond might influence parenting, and have a specific effect on parental communication and early language exposure. Understanding if and how prematurity affects parental communication is important, as disruptions to parental communication could compound built-in vulnerabilities in the preterm infant if they are receiving impoverished communication input from their caregivers.

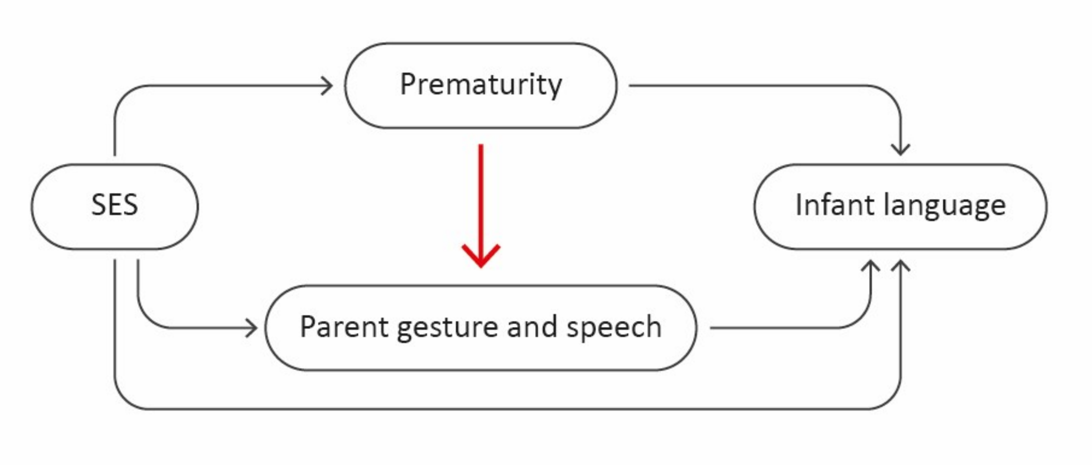

Figure 4-1 Relationship of interest: effect of prematurity on parent gesture and speech

Moreover, parental communication may be different if it is formulated in response to different needs and responsivity demonstrated by the parents of preterm infants. This includes the possibility that parental communication could be influenced for the better by prematurity, resulting in highly sensitive parents that are better able to adapt their responsivity, including their language, to their infant. In this chapter, I will review the literature on the communication of parents of preterm infants. I will then present the first study in this thesis which examines the relationship between prematurity and parental communication; operationalized as parent language and gesture during parent child play, see figure 4-1.

4.2 Introduction

4.2.1 Impact of the neonatal intensive care unit on parents and infants

Right from birth, preterm infants are exposed to a different linguistic environment than infants born at term. As discussed in chapter 2, preterm infants are exposed to significantly increased levels of noise than their term born counterparts (Wachman and Lahav, 2011). This increased levels of noise can have significant impact in terms of stress but also has important implications regarding the kinds of sounds infants are being exposed to (Philbin, 2000). Preterm infants are exposed to less maternal language in the NICU, compared to a fetus of the same gestational age who has maternal voice as the most prominent noise stimulus. This is important to consider as exposure to maternal voice plays a crucial role in early infant development. Given the evidence suggesting that early language experience is necessary for typical language development, the potential disparity in preterm infant's linguistic environment may have negative language based effects (Caskey et al., 2011).

A recent meta-analysis, found that maternal speech can play an important role in preterm infant stability, including physiological and behavioural measures (Filippa et al., 2017). When presented with recordings of recorded or live maternal voice, infants displayed more cardiorespiratory stability and had reduced critical respiratory events (Filippa et al., 2017). It is important to note however, that the authors highlight that there are significant methodological difficulties, such as differences in NICU organisation, heterogeneous sound environments, and the vast variety of health complications experienced by preterm infants, that make it difficult to directly compare study designs. A recent systematic review identified 18 papers from 1996 to 2016 that examined the effects of maternal voice on preterm infants (Provenzi et al., 2018). While results regarding physiological changes, such as heart rate variability, in infants were mixed, robust patterns regarding cognitive development were found. Specifically, researchers found that infants made significantly more conversation turns when parents were present than when they were absent (Caskey et al., 2011). While this study did not include a term born comparison, the evidence demonstrating increased infant vocalisations following exposure to parental language is compelling. In addition, they found that exposure to maternal voice was predictive of later general language and cognitive development, suggesting that these very early linguistic experiences can have lasting implications (Caskey et al., 2014).

4.2.2 Factors influencing the communication of parents of preterm infants

In addition to a decrease in exposure to maternal voice, spending time in the NICU is stressful for both infants and parents (Lefkowitz et al., 2010). Parents have been found to experience feelings of stress, depression, and a lack of control over the situation (Obeidat et al., 2009). Parental stress is associated with decreased cognitive abilities at 5 years of age in infants born preterm, suggesting that parental stress can have long lasting implications for infant development (Lean et al., 2018). It has been suggested that increased language risk in preterm infants may be a result of stressed mothers interacting less with their infants and thus providing fewer language exchanges in the process (Cusson, 2003). Consequently, preterm infants may be experiencing a language deprived environment as a consequence of parental stress (Cusson, 2003).

Maternal sensitivity is also thought to play an important role in shaping early infant language development, though it's relationship with prematurity is yet to be unpacked. As mentioned above, some suggest that mothers of preterm infants display increased levels of stress which results in lower sensitivity. In contrast, some argue that mothers of preterm infants display increased maternal sensitivity, which in turn is associated with increased receptive language scores in preterm infants

(Magill-Evans and Harrison, 2001). More responsive maternal interactions are associated with higher receptive language scores, which the authors suggest may result from a linguistically rich environment provided by responsive mothers (Magill-Evans and Harrison, 2001).

Salerni and colleagues coded 18 mother-preterm dyads and 14 mother-term infant dyads during a play session (Salerni et al., 2007). They coded for both maternal and infant language output. They found no significant group differences between the language input of preterm vs. term mothers, as measured by MLU, type/token ratio, quantity of tokens and types per minute, and utterances per minute. Although they did find differences in the language output of preterm vs. term infants, the maternal linguistic input was found to be the same between both groups with mothers from both groups using similar quantity and diversity of language. Speech directed at term and preterm infants was of a similar quality, with similar distributions of descriptions, commands and interrogative sentences. Differences in preterm and term infant language output, centred on spontaneous language production. Specifically, preterm infants were found to produce less spontaneous vocalisations and were less likely to initiate conversational turns. In contrast, mothers of preterm infants were more likely to add conversation during a silent pause than mothers of full term infants. The authors suggested that this could be indicative of preterms being more passive during the play session, as preterm infants appeared less responsive and less involved in the interactions with caregivers. They also suggested that the observation of mothers of preterm infants playing a more active role in initiating conversational turns, demonstrates the preterm mother's ability to respond appropriately and sensitively to their infant.

In a similar fashion, Benassi and colleagues compared maternal responses in 20 preterm and 20 term groups to examine if mothers of preterm infants responded less frequently and less relevantly to their infants spontaneous gesture and vocalisations (Benassi et al., 2018). Given that preterm infants produced a lower frequency of advanced gestures, Benassi and colleagues predicted that mothers of preterm infants would show a reduced volume of contingent and relevant responses as a result of the less advanced communicative behaviours of preterm infants. Interestingly, the results of the study did not support their hypothesis, instead showing no difference in the volume of contingent and relevant responses of mothers of preterm vs term born infants (Benassi et al., 2018). Taken together, the results of Benassi and Salerni suggest that parental communication between parents of term born and preterm infants appears similar, despite differences in the responsiveness of preterm vs. term infants. These results suggest that mothers of preterm infants are producing similar patterns, or even elevated patterns, of communication, despite the increased passivity of their infants.

In contrast, Gogate and colleagues examined object naming and word mapping in mothers of preterm vs. term infants (Gogate, 2020). They found that mothers of preterm infants used less adaptive word naming, and that preterm infants were less responsive to maternal naming, suggesting increased passivity in infants and decreased effective communication in mothers. The author suggested that these results are an argument for earlier interactive language interventions for preterm infants and their parents, in an effort to understand how to mitigate language delays. However, it is important to note that this study did not match term infants with preterm infants corrected age, which is in opposition to current prematurity research practices.

While some studies have found that mothers of preterm infants are more vocally responsive to their infants (Barratt et al., 1992), others find no difference in the level of vocal responsiveness between mothers of term born and mothers of preterm infants (Stevenson et al., 1988). It is clear that the evidence for prematurity influenced changes in parental communication are mixed. Nevertheless, we know that preterm infants are at an increased risk for later language delays, and it is important to examine whether or not they are exposed to different parental communication than their term born peers. While the increased language risk in preterms could be due to neurobiological reasons, it may also be due to differences in early linguistic exposure. While the literature suggests there is no difference in parental communication between parents of term born and parents of preterm infants, there are too few studies to be certain that there is no small effect which might nonetheless be clinically significant. Even subtle shifts in parental communication can have profound effects on infant language outcome (Lowe et al., 2019; Rahkonen et al., 2014). Moreover, the current evidence is limited by small sample sizes and does not consider the role of non-verbal linguistic input such as parental gesture. As discussed in chapter 2, early infant exposure to gesture can have important and long lasting implications for their later language development (Iverson et al., 1994; Schmidt and Lawson, 2002).

Before infants are verbal, preterm infants show delays in social-communicative development. Preterm infants display less vocalisations and are less active in initiating interactions (De Groote et al., 2006; Reissland and Stephenson, 1999). Some research suggests that mothers of preterm infants are more likely to be described as controlling and over stimulating, while preterm infants have been described to be more passive and less socially involved than their term born peers (Suttora and Salerni, 2011). Some suggest that this discrepancy between parent and infant communication patterns might result in asymmetric dyadic interactions (Bozzette, 2007). This could have important implications in terms of communication. If mothers of preterm infants have less functional dyadic interactions this could lead to potential differences in linguistic environment that, in turn, may lead to an increased risk of later language issues in the already more vulnerable preterm population.

Suttora and Salerni found that mothers of preterm children adjusted their lexical and syntactic complexity to the increased communication skills of their infants, similarly to mothers of term infants (Suttora and Salerni, 2011). The authors highlight that maternal communication did not differ as a function of prematurity, but was instead influenced by individual infant achievements in vocal and motor development. This suggests that mothers of preterm infants are tailoring their language to their individual infant’s abilities, in a similar way to that seen in mothers of term born infants (Suttora and Salerni, 2011).

Despite the significant volume of literature on the effect of parental communication on later infant language development, there is limited literature on any potential differences in the parental communication exposure of term born and preterm infants. As we know that preterm infants are at an increased risk for later language delays, it is important to examine whether or not they are exposed to different parental communication input, through both language and gesture, than their term born peers. Moreover, if there are differences in parental communication of parents of term born and preterm infants, it is important to understand the mechanism through which this relationship operates.

In this study, I will first compare the language and gesture rate, of parents of preterm and term born infants. Through this comparison, I will uncover any potential differences in the communication, measured through language and gesture, of parents from both groups. I will then compare parental language and gesture rate to markers of prematurity, to see if any significant correlations can be detected. This will allow us to understand if a) there are differences in the communication output of parents of preterm vs. term infants and b) if any of the observed differences are due to factors relating to prematurity.

4.3 Methods

4.3.1 Participants

Data were collected from 100 participants in total. The term born group consisted of 53 infants born >32 weeks gestation (mean gestational age of 39 weeks, range of 36-42 weeks). The preterm group consisted of 47 infants born <32 weeks gestation (mean gestational age of 29 weeks, range of 24-31 weeks). All participants were recruited as part of the larger TEBC study as discussed in chapter 3.3.1. Data collected from all 100 participants were included in the analyses. Parent-infant dyads were assessed at 9 months corrected (range of 8-10 months) for the preterm group and 9 months (range of 8-11 months) for the controls. See table 4-1 for demographic information on participants pertaining to prematurity and table 4-2 for information on gender, clinical comorbidities and feeding practices.

Measure		Mean	Standard Deviation	Minimum	Maximum	Skew	Kurtosis
Birthweight (grams)	Preterm (n=47)	1315	354	600	1950	-.13	-.92
	Term (n=53)	3556	466	2556	4580	.23	-.19
Gestational age/weeks	Preterm (n=47)	29.13	1.66	24	31	-.92	.51
	Term (n=53)	39.28	1.23	36	42	-.25	.31

Table 4-1 Prematurity demographics

		Valid N	Missing N	Preterm	Term
Gender	Male	58	0	30	28
	Female	42	0	17	25
Clinical comorbidities	Sepsis	5	2	5	0
	NEC	1	2	1	0
	BPD	7	3	7	0
Feeding practices (at discharge from NNU)	Breastfeeding	71	2	27	44
	Formula	9	2	7	2
	Mixed	18	2	11	7

Table 4-2 Sample demographics; gender, clinical comorbidities, feeding practices

4.4 Design

This study was a between-subject design. The independent variable was preterm or term born status. A range of dependent variables relating to parental communication were assessed including measures relating to gesture and vocabulary, detailed below.

4.5 Materials

For a more detailed account of the materials used for this study see chapter 3.

Demographic data were collected at the neonatal time point, or captured from the clinical record, including prematurity factors such as gestational age, and birthweight. Data for gestational age, and birthweight were uploaded to the TEBC RedCap database, and then extracted directly from there for the analyses in this chapter. During the parent child play, all parent and infant dyads had access to the same selection of toys; as described in chapter 3. A Sony video camera was used to record the parent-child interaction.

4.6 Procedure

Participants were consented into the TEBC as outlined in chapter 3. Data for this chapter were collected as a part of the 9-month appointment as outlined in chapter 3.

During the parent-child interaction, parents were instructed to play with their infants as they would normally do at home. Parent and infant dyads were placed on a colourful mat and presented with a series of toys. Parents were aware that they would be videotaped. After ensuring that the video camera was successfully recording, researchers left the room for 11 minutes. At the end of the parent-child interaction, the toys were removed for the remainder of the appointment. Video footage was uploaded to a secure university computer via a USB cable. Each individual video was uploaded into ELAN for coding. Only 10 minutes of each video was coded.

Following the data collection appointment, videos were first coded for parental language. Everything said by the parent during the video was coded for transcriptions, divided into utterances. As described in chapter 3, utterances were defined as a change in conversational turn, change in intonation, or a silence for at least 10 milliseconds. Utterances unidentifiable as words were coded phonetically. See chapter 3 for a more detailed account of the coding scheme. These transcriptions were then uploaded into CLAN and coded for total utterances, MLU, word types, and word tokens. Each individual transcription was run on CLAN using the [@freq] and [@mlu] commands.

The videos were then watched in ELAN a second time to code for gesture production. All hand movements made by parents were coded as gesture. Gesture categories included manipulating object, manipulating infant, pointing, giving, or other. “Manipulating object” included any instance of the parent moving or manipulating an object. “Manipulating infant” included any instance where a parent physically interacts directly with the infant. “Giving” involved any instance of the parent holding an object out with the intention of giving it to the infant. “Pointing” included any gesture used to indicate towards a particular object/location of interest through the use of a single finger extended outwards. Finally, “other” was defined as any gesture that does not fit into the classification codes detailed previously. See table 4-3 for what was included and excluded for both language and gesture codes. See table 4-4 for a comprehensive list of the variables included in this chapter.

Included (language)	**Excluded (language)**	**Included (gesture)**	**Excluded (gesture)**
Words	Non-syallabic noises	Manipulating object	Parent touches own face
Utterances identifiable as words	Laughter	Manipulating infant	Parent adjusts own clothing
Parental babbling	Mouth and lip manipulations	Pointing	Parent shifts own body
Transliterated sounds	Coughing	Giving	Parent stretches
Vocalised exhales	Vocalised inhales	Other	

Table 4-3 Coding inclusions and exclusions

4.7 Analysis methods

All analysis was done using SPSS 24. A sensitivity power analysis was conducted using G*Power to examine comparison of two independent group means using a two-tailed test, an alpha of .05, and anticipating a moderate-large effect size of d=.60. Results showed that our sample of 100 participants was sufficient to achieve a power of .85 (Faul et al., 2007). The independent variables were preterm or term born status and markers of prematurity including birth weight, and gestational age. Dependent variables were parental gesture and vocabulary measures. Specifically, these were gesture rates in each gesture category (total number of gesture, manipulating object, manipulating infant, pointing, giving, and other), number of word types, number of word tokens, type/token ratio and mean length of utterance. See table 4-4 for a list of the variables included in this chapter.

Conceptual Domain	**Variables**	**Description**
Prematurity	Birthweight	Birthweight, in grams, of infant measured at birth
	Gestational age at birth	Gestation of pregnancy, measured in weeks, at birth.
Language	MLU	Average length of utterance
	Word types	total number of different words spoken
	Word tokens	total number of words used during the interaction
	Type/token ratio	number of word types divided by the number of word tokens
Gesture	Manipulating object	any instance of the parent moving or manipulating an object.
	Manipulating infant	any instance where a parent physically interacts directly with the infant
	Giving	any instance of the parent holding an object out with the intention of giving it to the infant
	Pointing	any gesture used to indicate towards a particular object/location of interest through the use of a single finger extended outwards
	Other	any gesture that does not fit into the classification codes detailed previously

Table 4-4 Study variables

Baseline stats were reported including mean, standard deviations, and medians for birthweight. An independent t-test was used to test for significant differences in all variables capturing language and gesture output between the parents of term and preterm infants. Language and gesture output was calculated as described in the procedure section of this chapter see section 4.6.

Data are continuous, randomly sampled and the sample is reasonably large, which accounts for all other necessary data assumptions. Descriptive statistics were used to check the normality of the data. Normality was assessed by visual inspection of histograms and Q-Q plots, as well as an examination of skew and kurtosis values. Data are considered to meet assumptions of normality if they have a skew value of <2.1 and a kurtosis value of <7 (Kim, 2013; West et al., 1995). Homogeneity of variance was assessed using Levene's test for equality of variances. Data were all considered normal as all values of skew were <2.1 and all values of kurtosis were <7.1. As data were all considered normally distributed we are able to report mean, standard deviation, minimum and maximum values.

Finally, Pearson's correlation was used to examine continuous relations between gesture and language variables, and gestational age at birth.

4.8 Results

4.8.1 Descriptive statistics

Gestational age differed significantly between groups ($t(98)=34.9$, $p<0.001$), with a mean difference of 10.15 weeks. Birthweight also differed significantly between groups ($t(98)=26.8$, $p<0.001$), with a mean difference of 2241 g. See table 4-1 for descriptive information pertaining to markers of prematurity. Gesture means are reported in table 4-5, and language means are reported in table 4-6.

	Term			Preterm		
Code	**Mean**	**St.Dev**	**Std. Error**	**Mean**	**St. Dev**	**Std. Error**
Manipulating object	146.64	44.38	6.10	151.72	38.94	5.68
Manipulating infant	22.85	19.68	2.70	21.81	17.06	2.49
Pointing	10.09	6.82	0.94	10.06	9.55	1.39
Giving	7.92	5.31	0.73	8.83	5.86	0.86
Other	6.08	6.89	0.95	4.30	4.54	0.66
Total gesture	193.58	45.28	6.22	197.32	45.54	6.64

Table 4-5 Gesture means (measured in frequency counts)

	Term			Preterm		
Code	Mean	St.Dev	Std. Error	Mean	St. Dev	Std. Error
Word Types	190.94	55.30	7.60	190.96	52.96	7.72
Word Tokens	572.72	201.09	27.62	559.09	214.44	31.28
Type/Token ratio	0.348	0.06	0.01	0.36	0.06	0.01
Utterances	170.68	50.88	6.99	169.96	55.19	8.05
Mean length of utterance	3.313	0.55	0.08	3.26	0.54	0.08

Table 4-6 Language means (measured in frequency counts)

4.8.2 Group differences in parental communication

There was homogeneity of variances for all gesture scores for both groups, as assessed by Levene's test for equality of variances. There were no significant differences in gesture rates between groups. Rates of manipulating infant ($t(98)=.281$, $p=0.779$), manipulating object ($t(98)=-.605$, $p=0.546$), pointing ($t(98)=0.019$, $p=0.985$), giving ($t(98)=-.811$, $p=0.419$), and other gestures

($t(98)=1.503$, $p=0.136$) were all similar between preterm and term groups. Additionally, there was no significant difference in total gesture rate between groups ($t(98)=-.411$, $p=0.682$).

There was homogeneity of variances for all language scores for both groups, as assessed by Levene's test for equality of variances. In terms of language, parents of term born infants (M=170.68, SE=6.989) had a marginally higher number of total number utterances than parents of preterms (M=169.96, SE=8.050). Similarly, parents of term born infants (M=3.313, SE=0.075) had a marginally higher mean length utterance than parents of preterm infants (M=3.26, SE=0.078). None of these were significant differences. Total number of word types ($t(98)=-.001$, $p=0.999$), word tokens ($t(98)=.328$, $p=0.744$), type/token ratio ($t(98)=-.980$, $p=0.330$), total number of utterances ($t(98)=.068$, $p=0.946$), and MLU ($t(98)=.487$, $p=0.627$) were not significantly different between parents of term and parents of preterm infants.

4.8.3 Correlations between communication and prematurity

As group comparisons revealed no significant differences in communication between groups, both preterm and term groups were analysed together.

Language and gesture scores were appropriately correlated with one another. Total number of gesture was correlated with word types (r=.231, p=0.021), word tokens (r=.305, p=0.002), type token ratio (r=-.319, p=0.001), and total number of utterances (r=.369, p=0.000).

There was a correlation between birthweight and other gestures (r=.201, p=.045) to the effect that infants with lower birthweights had mothers who made fewer gestures in the "other" category. However, this did not survive a Bonferroni correction for multiple comparisons (corrected significance threshold, p=0.004).

4.9 Discussion

The results of this study showed that parents of term born and parents of preterm infants produce similar rates of language and gesture when interacting with their infant during a parent child play session. From these results, it appears as though parents of term born infants and parents of preterm infants, communicate with their infants in similar ways in late infancy, and there was a notable lack of difference between groups on a rich and diverse range of speech and gesture variables. This is in line with results found by Salerni and colleagues, who observed no significant group differences between the language output of mothers of term born and mothers of preterm infants (Salerni et al., 2007). It also supports results found by Benassi and colleagues, who found that mothers of term and preterm infants displayed similar levels of sensitivity and relevant responses when communicating with their infant (Benassi et al., 2018). The findings in this study add weight to the literature, and show that previous studies that found no difference between mothers of term born and mothers of preterm infants were not merely underpowered or limited by small sample sizes.

It is worth noting that the kinds of gestures observed in the parent child play may have been influenced by the materials provided to the parents. As all toys were within reaching distance, this may have limited the number of pointing gestures, and facilitated the high volume of manipulating object codes.

Additionally, we found that children with higher birthweight had parents who gestured more in the "other" category. This category included gestures that do not fit into the other categories laid out within the coding scheme and includes movements such as clapping and iconic gestures that did not involve the use of an object, such as making bunny ears with the index and middle finger. As a result, it is difficult to make any sort of confident conclusions as to why this correlation might exist. It is worth noting that the single most common gesture in the "other" category was clapping, often done as a result of ritualized parental singing with infants, or applauding a successful movement by the infant, such as stacking the bricks or rolling the ball. As a positive correlation was found, meaning that the frequency of other gestures increases with birthweight, it could be that infants who had a higher birthweight were exhibiting advanced development that led to an increased likelihood of receiving parental applause. However, the borderline significance, which did not survive correction, combined with a lack of any demonstrable relations between other forms of gesture and birthweight suggests that this correlation may have little practical import.

As there was no obvious pattern of effects between language and gesture and gestational age and birthweight, it appears as though there is no significant correlation between prematurity and parental language output. Pointedly, parents of preterm and parents of term born infants are all providing similar communication outputs for their infants, in this sample measured at 9 months. However, we did not measure reciprocity of language and did not code for synchronicity of vocalisations with infants which may have yielded group differences. It could be that while parents between both groups are using similar volumes and quantity of language, the timings or relationship with infant speech may be different. Moreover, although the language and gesture measured in this study offer a descriptive picture of how parents are communicating verbally and nonverbally with their infant, it does not offer information as to the infant's response.

In chapter 2.2.2, I discussed the social interactionist theory of language development which suggests that infant language development involves an interplay between biological and social factors. The results of the study presented in this chapter suggest that parental communication does not differ between parents of preterm and parents of term born infants. Thus, the increased risk of language delay so often cited within the preterm community may be resulting from either a biological factor, or a different social factor beyond differences in parental communication as a result of prematurity. Having established that there are no substantive, group-level differences in parental communication for parents of preterm versus term-born children, I now ask if there are other co-variates of language exposure that may contribute to later language development of term and preterm infants. The following chapter will examine if there are any socioeconomic influences in the language exposure experienced by both preterm and term born infants.

5 Effects of familial factors on parental communication during parent child play

5.1 Overview

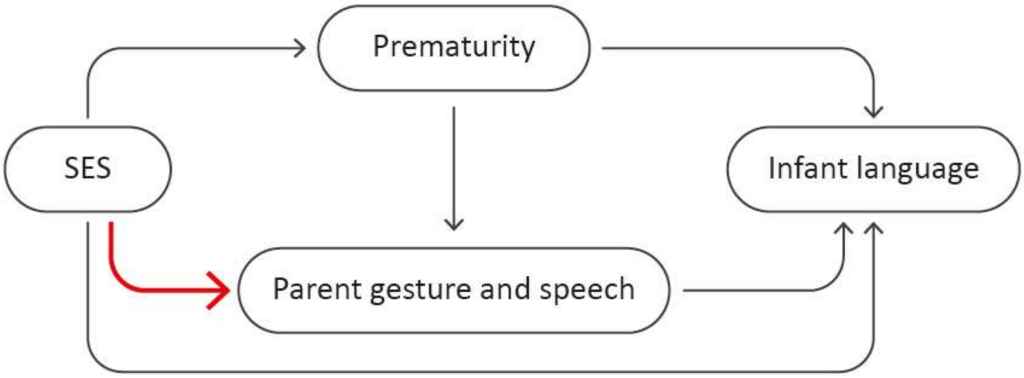

Figure 5-1 Relationship of interest: SES and parent gesture and speech

In chapters 1 and 2, I demonstrated the increased risk of language delay unequally experienced by infants from low SES households (Hart and Risley, 1995; Huttenlocher et al., 2010; Pungello et al., 2009). I also discussed that the over-representation of children from a low SES on measures of language is thought to result, in part, from a lack of exposure to parental language and/or a lack of access to resources (Bradley et al., 2001; Hoff, 2003; Vernon-Feagans and Bratsch-Hines, 2013). Therefore, understanding how SES affects parental communication is vital in unpacking the increased risk of language delay in low SES infants. Moreover, it is important to understand if SES related effects on parental language are evident as early as within the first year of life, and few studies have examined SES and language effects in parents of preverbal infants.

Additionally, given the evidence surrounding the importance of early gesture exposure, it is important to understand if parental gesture is also impacted by SES, as less is known about this possible interaction. In this chapter, I will briefly discuss the literature that examines the effect of familial factors, such as SES, on the verbal and gestural communication of parents with their infants. I will also discuss other factors that co-occur with deprivation, such as level of education, which may also play a role in shaping the verbal and nonverbal communication of parents. In order to understand the SES related effects on parental language, it is important to unpack if deprivation or level of education is driving the relationship. Finally, I will present the second study of this thesis, which attempts to understand if any familial factors, including SES, maternal education or quality of life, affect the language and gestures parents use when communicating with their infants during an episode of parent child play. See figure 5-1 for a visual outline of the relationship of interest in this chapter.

5.2 Introduction

5.2.1 SES differences in language learning environment

As discussed previously in chapter 2, SES can have important and long-lasting effects on infant language development (Huttenlocher et al., 2010). It is suggested that some of the SES related differences in infant language development may be due to differences in parental language input. There is robust evidence suggesting that children from low SES homes are exposed to fewer words than their high SES peers (Hart and Risley, 1995). This has important and long-lasting consequences regarding the learning trajectories of children from low SES backgrounds (Hirsh-Pasek et al., 2015). Evidence suggests that both the quantity and quality of language exposure experienced by a child helps to shape their later development (Hirsh-Pasek et al., 2015). Thus, if children from lower SES homes are exposed to less quantity and variability of language, this could lead to a potential disadvantage for their later language development.

Hoff et al argued that observed SES related language differences in children were a result of SES related differences in the language learning environment that they experienced (Hoff, 2003). In their study, high SES mothers used more utterances, word types and tokens, and had a higher MLU. These mothers also produced more topic continuing replies when conversing with their children, which is indicative of their attempt to continue conversation and encourage a dyadic interaction with their child. The authors argued that children who are exposed to longer utterances and a more varied vocabulary display a faster rate of vocabulary growth as a result. Although compelling evidence, it is important to note that this study compared high and mid SES groups and did not have a low SES group for comparison. Although there are still SES related differences in parental language output, the lack of a lower SES group makes it difficult to understand the potentially compounding effect of deprivation. It is also important to note that this study relied on samples of spontaneous speech as a child outcome measure, which may not be an accurate representation of child language development at that particular time point. (Hoff, 2003).

5.2.2 Effect of maternal education on language output

While level of education is often used as a proxy for SES in research (Braveman et al., 2005), it could be interacting with child language development in ways outside of socioeconomics. Although high levels of SES are likely to be associated with high levels of education, maternal education could also be having direct influence on the language caregivers are using when interacting with their infants. Mothers with more education are more verbally responsive and are more likely interact with their child in ways similar to formal teaching, such as asking questions rather than offering directives (Tracey and Young, 2002).

Maternal education has also been found to be a small predictor of the volume of maternal language (Hoff-Ginsberg, 1994). Rowe and colleagues found relationships between both child directed speech and parental education, and between child directed speech and SES measured as income (Rowe, 2008). Parents with more education and economic advantage talked more, used longer utterances, and had more diversity in words. More educated and economically advantaged parents also had increased knowledge of child development, which appears to mediate the relationship between SES and parental speech. The authors suggest that observed SES related differences in parental speech were due to differences in parents' knowledge of child development. The authors suggested that parents who had more knowledge of child development could be "in tune" with the language abilities of their child and better able to adjust their speech accordingly. This is important as other studies have found that the quality of interaction, operationalised as joint engagement and fluent communication, between mothers and infants was an important predictor for later language ability, above the quantity of maternal words and sensitive parenting (Hirsh-Pasek et al., 2015). This suggests that not only is the volume and diversity of language used by parents important, but that the synchronisation of communication with infants also has important developmental implications.

Huttenlocher and colleagues found that SES was a highly significant predictor of all measures of child language diversity. This effect remained true when SES measures were either parental level of education or family income. The SES related effects were found to be mediated by parental speech, and the authors suggested that SES related language differences reflect variations in parental speech, which in turn affects children's later language growth (Huttenlocher et al., 2010). Korpilahti and colleagues found that parental education and social class were positively associated with children's language comprehension. They also found that mother's concerns regarding their child's language were reliably correlated with limited expressive vocabulary and poor language comprehension. The authors argue that this is evidence in support of accurate maternal concerns regarding their child's language (Korpilahti et al., 2016).

5.2.3 Effect of additional familial factors on the language learning environment

Given the evidence that environmental stimulation is imperative for infant language development, it is worth exploring what familial factors in addition to SES can influence a child's language environment. As discussed in chapters 1 and 2, SES is a multifaceted construct and it could be that the mechanism through which SES affects parental communication is due to factors beyond education level, and may be more influenced by increased levels of deprivation or decreased quality of life.

Maternal depression has been linked to children's later risk for cognitive and language difficulties (Sohr-Preston and Scaramella, 2006). Moreover, women who have infants with sleep problems are more likely to report symptoms of depression (Hiscock, 2002). A randomised controlled study found that a sleep intervention was successful not only in improving infant sleep but also in decreasing symptoms of maternal depression (Hiscock, 2002).

It has been suggested that mothers experiencing postpartum depression may influence their infant's emerging language skills. This could be due to mothers experiencing postpartum depression struggling to meet their infants' needs, displaying less responsive parenting, or an inability to shape the environment to foster learning opportunities (Sohr-Preston and Scaramella, 2006). Depressed mothers are more likely to have lower levels of vocal and facial expression, and are more likely to use a more monotonous tone of voice when communicating with their infant (Breznitz, 1992). In other words, depressed mothers display less of the traditional facets of language seen in typical "motherese". This lack of infant-directed speech, or motherese, has been found to have a negative effect on infant learning (Kaplan et al., 2002). Mothers experiencing depression are also found to have difficulty in establishing and maintaining joint attention with their children (Goldsmith and Rogoff, 1997). Finally, maternal depression may influence mothers ability to use play and shared book reading as an opportunity to enhance child language development (Sohr-Preston and Scaramella, 2006). Consequently, mothers who are experiencing depressive symptoms may be less able to supply a saturated infant language learning environment.

It is worth nothing that researchers have found a moderating relationship between SES and maternal depression (Stein et al., 2008). Children of high SES mothers experiencing depression are found to exhibit less adverse language outcomes than children of low SES mothers experiencing depression. It appears as though a high

SES may have a protective effect against the potentially negative effects of maternal depression on infant language development (Kurstjens and Wolke, 2001).

Other quality of life factors, such as household instability, high levels of noice, excessive crowding and a lack of structure, have been posited to affect children's language environments (Vernon-Feagans et al., 2012). Exposure to neighbourhood noise and residential crowding is negatively related to children's language development, even when controlling for SES measured by household income, suggesting that some quality of life factors can have long term effects independent of SES (Evans et al., 1998; Vernon-Feagans et al., 2012). Other studies have found that high levels of residential noise and crowding are associated with higher occurances of parental verbal interference, less giving of objects, and less reciprocation to children's attempts at communication, suggesting that household factors may directly influence parental behaviours and communication environments, which in turn has important consquences of infant language development (Matheny et al., 1995).

5.2.4 SES differences in nonverbal communication

It is important to note that both the quantity and quality of language and gesture children are exposed to is important. As discussed in chapter 2, when children are exposed to a diverse vocabulary it has important implications for their own receptive and expressive language skills (Bornstein et al., 1998). Gesture is also known to serve a critical role in children's language development, and early exposure to adult gesture has important implications similar to the value of early language exposure (Rowe and Goldin-Meadow, 2009). Additionally, exposure to adult gesture directly impacts children's language learning, with high levels of gesture associated with increased comprehension and communication in children (Iverson et al., 1994; Zammit and Schafer, 2011).

SES related differences in parental non-verbal communication have been less studied than SES related differences in parental verbal communication, but there are promising signs of important SES related effects. Parents with higher levels of education have been found to use pointing more to direct child attention and conversation (Rowe, 2000). As pointing can have important implications for joint attention and language development, an increased rate of exposure to pointing may act as an advantage for later language outcomes (Iverson et al., 1994). The increased rate of gesture in high SES homes also has important implications for preverbal infants, as gesture is viewed as an early way in which parents can foster joint attention, encourage children to orient themselves to points of interest, and help support early label learning (Schmidt and Lawson, 2002). Caregivers from low SES households are found to respond less to child initiated gesture, and to provide less gesture models than caregivers from higher SES households (Rowe and Goldin-Meadow, 2009). Thus, it is worth examining the language and gesture used by parents, especially while the infant is preverbal, to understand the very early implications of parental communication input.

5.3 This study

While there is significant evidence outlining the effect of SES on parental language, less is known about the interaction between SES and parent gesture. Moreover, few studies have examined SES and language in parent infant dyads where the infant is nonverbal. By examining these early preverbal interactions, I am able to provide a highly detailed account of early parent language and gesture to add to our understanding of the very early linguistic exposure experienced by infants of varying SES backgrounds. Specifically, in this study I will measure the use of vocabulary and gesture of parents when communicating with their infants during a parent child play session. From this, I will compare the vocabulary and gesture rates to see if SES influences the way in which parents are communicating. I predict that SES related differences in language and gesture use will be detected through the use of the novel coding scheme described in chapter 3. I will also look at other parental lifestyle factors, including WHOQOL-BREF scores and Sleep and Settle scores, to observe if any quality of life assessments are associated with parental language, operationalised as parent gesture and vocabulary during parent child play.

5.4 Methods

5.4.1 Participants

Data were collected from 100 participants in total. The term born group consisted of 53 infants born >37 weeks gestation. The preterm group consisted of 47 infants born <32 weeks gestation. All participants were recruited as part of the larger TEBC study in which this thesis sits. Data collected on all 100 participants was included in the correlational analysis. Data on 78 infants was included in the regression analyses investigating associations between SES and WHOQOL-BREF scores and language input, while 87 infants were included in the regression including the Sleep and Settle scores. The discrepancy in participant numbers was due to missing data using a listwise exclusion for the regression.

Measure		Mean	Standard Deviation	Minimum	Maximum	Skew	Kurtosis
SIMD 2016 rank	Preterm (n=43)	4180	2036	137	6929	-.30	-1.14
	Term (n=49)	4638	1914	727	6936	-.60	-1.01
Maternal level of education	Preterm (n=43)	4.49	1.40	1	6	-.90	.24
	Term (n=49)	4.88	1.24	1	6	-1.83	3.26
WHOQOL-BREF raw scores	Preterm (n=38)	8.18	1.290	5	10	-.52	-.16
	Term (n=50)	8.60	1.44	4	10	-1.12	.88
SSQ "Bother" scale raw scores	Preterm (n=39)	16.36	6.31	8	37	1.08	1.55
	Term (n=53)	16.91	5.40	9	29	.56	-.47

Table 5-1 Sample demographics

5.4.2 Design

This study was a between-subject design. The independent variables were familial factors including SES, maternal education, WHOQOL-BREF and Sleep and Settle bother scores. A range of dependent variables included gesture counts, and parental language factors including mean length utterance, word type, word tokens, and total number of utterances.

5.4.3 Materials

5.4.3.1 SES

As described in section 1.3.1, SES was measured using the Scottish Index of Multiple Deprivation 2016, or SIMD 2016 (Scottish Government, 2016). The SIMD is a multiple measure tool used by the Scottish government to rank small areas, referred to as data zones, from most deprived to least deprived (Scottish Government, 2016). The SIMD splits Scotland into 6,976 data zones all with similar population sizes. These data zones are then examined for multiple indicators of deprivation, which are then are grouped into seven domains (employment, income, crime, housing, health, education, access), which are finally grouped into one SIMD. This results in each data zone in Scotland being ranked from 1 (most deprived) to 6,976 (least deprived), (Scottish Government, 2016). SIMD scores were therefore collected based on the participants' self-reported postal code. Participants in this study had a wide range of SIMD scores. See table 5-1 for additional demographic information on the participants included in this study.

5.4.3.2 WHOQOL-BREF

Parents completed the WHOQOL-BREF questionnaire as part of the questionnaire pack provided prior to the appointment. The WHOQOL-BREF is an abbreviated version of the WHOQOL-100 quality of life assessment (Webster et al., 2010). The WHOQOL-100 includes 24 facets that have been deemed important in assessing quality of life. The 24 facets produce scores in four domains, all of which are also captured in the WHOQOL-BREF. These four domains are physical health, psychological, social relationships, and environment. See table 5.2 for examples of what is included in each domain. Additionally, the WHOQOL-BREF includes questions relating to overall quality of life. The WHOQOL-BREF was chosen instead of the WHOQOL-100 as it is a valid and reliable alternative that takes significantly less time to complete, containing 26 questions in comparison to the 100 questions found in the WHOQOL 100. Internal consistency of the WHOQOL-BREF is measured using Cronbach alpha, with values for each domain score ranging from 0.66 to 0.84 (The Whoqol Group, 1998). Domain scores calculated from the WHOQOL-BREF and the WHOQOL 100 are shown to be very similar, with correlations ranging from 0.89 to 0.95 (The Whoqol Group, 1998). Additionally, test-retest for the WHOQOL was found to range from 0.66 to 0.87 (The Whoqol Group, 1998). WHOQOL-BREF has been found to have good discriminant validity between known groups of depressed and non-depressed women following childbirth (Webster et al., 2010). See table 5-2 for information on the WHOQOL-BREF scores included in this chapter.

Domain	**Examples of what is being measured**
Physical health	Pain, sleep, energy, mobility, dependence on medication, work capacity
Psychological	Positive feelings, concentration, self-esteem, body image, negative feelings, spirituality
Social relationships	Personal relationships, social support, sexual activity
Environment	Physical safety, home environment, finances, health and social care, transport

Table 5-2 WHOQOL-BREF domains

5.4.3.3 Maternal education

Maternal education was collected via a questionnaire directly administered to the parents by a research nurse at the post-natal appointment. Parents were asked what their final educational qualification was and offered 7 options of answers; None; 1-4 GCSE passes at GSE; GCSE, O level; >5 passes at CSE, GCSE, O level; A levels of Highers or equivalent; College qualification (eg. NC, HND, HNC, etc); University; Postgraduate degree; N/A. Maternal education was not included as a proxy of SES. SIMD 2016 was used as a measure of SES, while maternal education was kept independent. As mentioned in the introduction of this chapter, although maternal educational level is often used as a measurement of SES, it is also found to have direct influence on the language mothers use for communication (Braveman et al., 2005; Tracey and Young, 2002). Thus, for the purposes of this study maternal education was kept separate from SES and examined as an independent variable, to assess if deprivation (measured via SIMD16) or maternal level of education had similar effects on parental communication.

5.4.3.4 Sleep and Settle-Bother Score

The Sleep and Settle Questionnaire, (hereafter the SSQ), was completed by a parent prior to their 9-month appointment. The SSQ is a questionnaire that provides information on an infant's sleep and settling behaviour as well as offers insights into the parents perspective regarding their infants sleep and settling behaviour (Matthey, 2001). It allows for the measurement of both day time and night time sleeping behaviours as well as offers insight into the parental perceptions of their infants sleep and their ability to manage their infant's sleeping. This is important as it has been suggested that there is significant overlap between maternal mood and infant sleep patterns.

The SSQ comprises 34 questions regarding infant sleep patterns and settling behaviours. Nine of the 34 questions asses the "degree of bother" experienced by the parent. These questions include daytime, evening and night-time related questions. A total "Bothered with sleep" score is then calculated from these and ranges from 9 (low bother) to 45 (high bother) (Matthey, 2001). See table 5-3 for a list of questions included on the bother scale. The SSQ has good validity and is a recommended clinical and research instrument (Matthey, 2001).

Day time bother
How much your baby needs to have your attention during the day How long it took me to get my baby settled for daytime sleeps
The amount my baby slept during the day
The amount my baby cried during the daytime
Evening bother
How long it took me to get my baby settled for the first sleep at night
The amount my baby cried during the evening
Night-time bother
How long it took me to get my baby resettled during the night
The amount my baby slept during the night
The amount my baby cried during the night

Table 5-3 Sleep and settle "bother scale" items

All parent and infant dyads had access to the same selection of toys during the parent child play described in chapter 3.4.2. A Sony video camera was used to record the parent-child interaction.

5.5 Procedure

Participants were consented into the TEBC as outlined in chapter 3.5.4. Data for the current analysis was collected as a part of the 9-month TEBC appointment. The procedure for data collection was identical to that described in Chapter 4 and will briefly be described below.

During the parent-child interaction, parents were instructed to play with their infants as they would normally do at home. Parent and infant dyads were placed on a colourful mat and presented with a series of toys. Parents were aware that they would be videotaped. After ensuring that the video camera was successfully recording, researchers left the room for 11 minutes. At the end of the parent-child interaction, the toys were removed for the remainder of the appointment. Video footage was uploaded to a secure University computer via a USB cable. Thereafter, each individual video was uploaded into ELAN for coding (Lausberg and Sloetjes, 2009). Precisely 10 minutes of each video was coded, starting from the moment that the parent and child were alone together in the room.

Following the data collection appointment, videos were first coded for parental language. Everything said by the parent during the video was transcribed and then divided into utterances. As described in chapter 3, utterances were defined as a change in conversational turn, change in intonation or a silence for at least 10 milliseconds. Utterances unidentifiable as words were coded phonetically. See chapter 4 for a more detailed account of the use of the coding scheme. These transcriptions were then uploaded into CLAN and coded for MLU and word types and tokens (MacWhinney, 2018). Each individual transcription was run on CLAN using the [@freq] and [@mlu] commands.

The videos were then watched in ELAN a second time to code for gesture production. See chapter 3 for more detailed information on the gesture coding procedure. Gesture codes were then exported into SPSS for analysis. See table 5-4 for the final coded variables included in this chapter.

Domain	Variables	Description
Familial	SIMD 2016	Post code measure of SES
	Maternal education	Level of maternal education
	WHOQOL-BREF	Quality of life assessment
	SSQ	Sleep and Settle bother score
Language	MLU	Average length of utterance
	Word types	The number of different words spoken
	Word tokens	The total number of words used during the interaction
	Type/token ratio	The number of word types divided by the number of word tokens
Gesture	Manipulating object	Any instance of the parent moving or manipulating an object.
	Manipulating infant	Any instance where a parent physically interacts directly with the infant
	Giving	Any instance of the parent holding an object out with the intention of giving it to the infant
	Pointing	Any gesture used to indicate towards a particular object/location of interest through the use of a single finger extended outwards
	Other	Any gesture that does not fit into the set classification codes

Table 5-4 Variables inluded in this chapter

5.5.1 Inter-intra rater reliability

Inter and intra-rater reliability was assessed through second coding, as described in section 3.7.3.

5.6 Analysis methods

All analysis was done using SPSS 24. Descriptive statistics were reported including mean, standard deviations, and medians for SIMD rank, maternal level of education, WHOQOL-BREF, and SSQ scores. Language and gesture output was calculated in terms of the categories laid out in table 5-4. The independent variables were familial factors including SIMD rank, maternal level of education, and WHOQOL-BREF scores. Dependent variables were parental gesture and vocabulary measures. Specifically, these were gesture rates in each gesture category (total number of gesture, manipulating object, manipulating infant, pointing, giving, and other), number of word types, number of word tokens, type/token ratio and mean length of utterance. Following the initial analysis, SSQ scores were added as an additional independent variable.

Descriptive statistics were used to check the normality of the data. Data are considered to violate the assumption of normality if they have a skew value of >2.1 and a kurtosis value of >7.1 (Kim, 2013). Homogeneity of variance was assessed using Levene's test for equality of variances. Normality tests were done on all parental variables including SIMD scores, maternal level of education, WHO-QOL, and SSQ scores. Normality was assessed by visual inspection of histograms and Q-Q plots, as well as an examination of skew and kurtosis values. Data were all considered normal as all values of skew were <2.1 and all values of kurtosis were <7.1. As data were all considered normally distributed we are able to report mean, standard deviation, minimum and maximum values. Data are continuous, randomly sampled and reasonably large, which accounts for all other necessary data assumptions.

A Pearson's correlation was run on gesture and language markers, and family factors including SIMD, maternal education and WHOQOL. Following this, a series of hierarchical regressions were run to determine the predictive capabilities of each of the variables of interest. Variables of interest were selected and inputted based on the results of the previous correlational analysis. Following the initial analysis, SSQ scores were included as an additional independent variable.

5.7 Results

5.7.1 Descriptive statistics

There were 53 term born infants and 47 preterm infants in the sample (n=100). There was no significant difference between preterm and term born infants for SIMD rank, ($t(90)=1.112$, $p=0.269$), maternal level of education ($t(90)=1.415$, $p=0.161$), WHOQOL-BREF scores ($t(86)=1.400$, $p=0.165$), or SSQ bother scores ($t(90)=.446$, $p=0.656$).

Measure		**Mean**	**Standard Deviation**	**MIN**	**MAX**	**Skew**	**Kurtosis**
SIMD rank	Preterm (n=43)	4180	2036	137	6929	-.30	-1.14
	Term (n=49)	4638	1914	727	6936	-.60	-1.01
Maternal level of education	Preterm (n=43)	4.49	1.40	1	6	-.90	.24
	Term (n=49)	4.88	1.24	1	6	-1.83	3.26
WHOQOL - BREF	Preterm (n=38)	8.18	1.29	5	10	-.52	-.16
	Term (n=50)	8.60	1.44	4	10	-1.12	.88
SSQ	Preterm (n=39)	16.36	6.31	8	37	1.08	1.55
	Term (n=53)	16.91	5.40	9	29	.56	-.47

Table 5-5 Mean SIMD, maternal level of education, WHOQOL-BREF and SSQ scores

5.7.2 Correlational analysis

As would be expected, gesture and language scores were positively correlated with one another. See table 5.6.

		Word types	Word tokens	Type/token ratio	Total number of utterances	Mean length of utterance
Pointing	Pearson Correlation	.425**	.396**	-.184	.444**	.059
	Sig. (2-tailed)	.000	.000	.067	.000	.560
Manipulating infant	Pearson Correlation	.072	.079	-.063	.088	-.037
	Sig. (2-tailed)	.476	.432	.531	.383	.718
Manipulating object	Pearson Correlation	.109	.174	-.229*	.218*	-.043
	Sig. (2-tailed)	.280	.084	.022	.029	.671
Giving	Pearson Correlation	-.064	-.005	-.125	.065	-.122
	Sig. (2-tailed)	.524	.959	.217	.518	.226
Other	Pearson Correlation	.241*	.257**	-.166	.274**	.043
	Sig. (2-tailed)	.016	.010	.098	.006	.672
Total gesture	Pearson Correlation	.231*	.305**	-.319**	.369**	-.052
	Sig. (2-tailed)	.021	.002	.001	.000	.611

Table 5-6 Gesture and language correlations; N=100

Similarly, familial markers were correlated with one another. SIMD was correlated with both maternal level of education (r=.290, p=0.007), and WHOQOL-BREF (r=.330, p=0.002).

See table 5-7 for the full correlation matrix comparing communication makers with SIMD, Maternal level of education and WHOQOL-BREF scores.

		SIMD rank	Maternal level of education	WHOQOL
Pointing	Pearson Correlation	0.138	0.056	0.124
	Sig. (2-tailed)	0.190	0.595	0.249
	N	92	92	88
Manipulating infant	Pearson Correlation	0.092	-0.144	.241*
	Sig. (2-tailed)	0.381	0.170	0.023
	N	92	92	88
Manipulating object	Pearson Correlation	0.064	-0.035	0.090
	Sig. (2-tailed)	0.543	0.740	0.407
	N	92	92	88
Giving	Pearson Correlation	-0.021	-0.133	-0.082
	Sig. (2-tailed)	0.844	0.205	0.448
	N	92	92	88
Other	Pearson Correlation	-0.106	0.003	0.065
	Sig. (2-tailed)	0.314	0.979	0.548
	N	92	92	88
Total gesture	Pearson Correlation	0.096	-0.102	0.196
	Sig. (2-tailed)	0.362	0.332	0.067
	N	92	92	88
Word type	Pearson Correlation	.258*	0.200	.231*
	Sig. (2-tailed)	0.013	0.056	0.030
	N	92	92	88
Word token	Pearson Correlation	.321*	0.137	.274**
	Sig. (2-tailed)	0.002	0.194	0.010
	N	92	92	88
Type/token ratio	Pearson Correlation	-.304**	0.083	-0.169
	Sig. (2-tailed)	0.003	0.433	0.115
	N	92	92	88
Total number of utterances	Pearson Correlation	0.202	0.034	0.201
	Sig. (2-tailed)	0.053	0.745	0.060
	N	92	92	88
MLU	Pearson Correlation	.373**	.285**	.230*
	Sig. (2-tailed)	0.000	0.006	0.031
	N	92	92	88

Table 5-7 Correlational matrix: Family factors and language and gesture markers

In terms of relationships between language and family factors, SIMD was significantly positively correlated with word types ($r=.258$, $p=0.013$), word tokens ($r=.321$, $p=0.002$), and MLU ($r=.373$, $p=0.000$). SIMD also showed a negative correlation with type/token ratio ($r=-3.04$, $p=0.003$). Maternal education was significantly positively correlated with MLU ($r=.285$, $p=0.006$) but no other communication variables. Finally, WHOQOL-BREF was significantly positively correlated with manipulating infant ($r=.241$, $p=0.023$), word types ($r=.231$, $p=0.030$), word tokens ($r=.274$, $p=0.010$), and MLU ($r=.230$, $p=0.031$). Thus, higher levels of status and well-being were related to larger volumes, greater complexity and greater variety of parental communication, while education related only to greater language complexity. These relations were prevalent for speech but not for gesture variables.

The negative correlation between SIMD and type/token ratio is unusual and the opposite directionality to what the literature and other results would suggest. This may be due to mathematical consequences rather than theoretical ones. As parents from a low SES background produced fewer types and tokens compared to parents from higher SES households, the type token ratio of this group is more susceptible to smaller changes in type or token value having a significant impact on the type token ratio. For a parent with a higher SES who is using a larger overall volume of word tokens, they would need a comparable increase in word types to achieve the same ratio. In other words, someone using few words can enlarge their type token ratio relatively easily because the word token ratio is so low, whereas someone who is producing a higher volume of word tokens would have a harder time producing such a high volume of word times. Moreover, given the context of the study, a parent child play with a preverbal infant, there is a limited vocabulary within which parents are communicating. Finally, the high volumes of parental babbling that occur during a parent child play at this time point would have significant effects on increasing the overall word tokens, without influencing the total number of word types. Thus, if parents from a high SES background engaged in increased levels of parental babbling with their infant, this would result in a decrease in their type token ratio, thus offering a potential explanation for the negative correlation between SIMD scores and type-token ratio.

5.7.3 Regression

Following the results of the correlational analysis, a series of hierarchical regressions were run to examine the relative effects of the variables examines. Based on the results of the correlation and given the strong volume of evidence in the literature, SIMD was chosen as the first predictor, followed by WHOQOL-BREF and maternal education.

5.7.3.1 Regression 1- MLU as dependent

For the first hierarchical regression, mean length of utterance was the dependent variable, with SIMD, WHOQOL-BREF and maternal level of education as predictors. There was independence of residuals, as assessed by a Durbin-Watson statistic of 2.125. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10).

	Model 1a		Model 2a	
Variable	B	β	B	β
Constant	2.87		2.58	
SIMD rank	9.96E-05	0.38	8.852E-05	0.34
WHOQOL-BREF			0.02	0.06
Maternal level of education			0.03	0.08
R^2	.147		.157	
F	13.14		4.60	
ΔR^2	.15		.01	
ΔF	.00		.65	

Table 5-8 Regression MLU dependent

Abbreviations: SIMD, Scottish Index of Multiple Deprivation; N=78

Model 1a revealed that SIMD accounts for 14.7% of the variation in parental MLU. The addition of WHOQOL-BREF and maternal level of education (Model 2a), led to an increase in R^2 of 0.01. This was not a statistically significant increase $F(2, 74)=.432$, $p=.651$. The full model of SIMD, WHOQOL-BREF, and maternal level of education to predict mean length utterance was $R^2=.157$, $F(3,74)=4.602$, $p=0.005$, adjusted $R^2=.123$. This model is significant.

5.7.3.2 Regression 2- Word types as dependent

The second regression used SIMD as the first predictor, followed by WHOQOL-BREF and maternal education. Word types was the dependent. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.777. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10).

	Model 1b		Model 2b	
Variable	B	β	B	β
Constant	163.08		123.30	
SIMD rank	0.00	0.22	0.00	0.17
WHOQOL-BREF			5.36	0.14
Maternal level of education			0.28	0.00
R^2	0.048		0.06	
F	3.81		1.70	
ΔR^2	0.048		0.017	
ΔF	3.81		.65	

Table 5-9 Regression Word types dependent

Abbreviations: SIMD, Scottish Index of Multiple Deprivation; N=78

Model 1b revealed that SIMD accounts for 4.8% of the variation in word types. The addition of WHOQOL-BREF and maternal level of education (Model 2b), led to an increase in R^2 of 0.064. This was not a statistically significant increase $F(2, 74)=.654$, $p=.523$. The full model of SIMD, WHOQOL-BREF and maternal level of education to predict the total number of word types was $R^2=.064$, $F(3,74)=1.696$, $p=.175$, adjusted $R^2=.026$. This model was not significant.

5.7.3.3 Regression 3- Word tokens as dependent

The second regression used SIMD as the first predictor, followed by WHOQOL-BREF and maternal education. Word tokens was the dependent. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.899. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10).

	Model 1c		Model 2c	
Variable	B	β	B	β
Constant	428.19		286.63	
SIMD rank	0.03	0.29	0.03	0.24
WHOQOL-BREF			26.49	0.18
Maternal level of education			-12.59	-0.08
R^2	.085		.116	
F	7.10		3.23	
ΔR^2	.085		.03	
ΔF	7.10		1.27	

Table 5-10 Regression word tokens dependent

Abbreviations: SIMD, Scottish Index of Multiple Deprivation; N=78

Model 1c revealed that SIMD accounts for 8.5% of the variation in word tokens. The addition of WHOQOL-BREF and maternal level of education (Model 2c) led to an increase in R^2 of 0.116. This was not a statistically significant increase $F(2,74)=1.266$, $p=.288$. The full model of SIMD, WHOQOL-BREF, and maternal level of education to predict total number of word tokens was $R^2=.116$, $F(3, 74)=3.226$, $p=0.027$, adjusted $R^2=0.80$. The full model was found to be a significant predictor.

5.7.3.4 Regression 4- SSQ

Our previous regressions revealed that SIMD, WHOQOL, and maternal education were able to significantly predict both parental MLU and word tokens. However, it did not significantly predict word types. From this, we decided to include the SSQ bother scores in our analysis. There is evidence to suggest that sleep deprivation can have a negative effect on language output, specifically to do with more cognitively taxing language demands (Pilcher et al., 2007). For this reason, we chose to further examine word types as an outcome measure, as producing a varied vocabulary is a more complex cognitive demand than language production and we predicted that sleep deprivation may have an effect on the variability of a mother's vocabulary. Moreover, given the literature surrounding the relationship between maternal depression and infant sleep, and the literature suggesting a relationship between maternal depression and language output, we decided to look at any potential infant sleep related effects on language. A correlational analysis revealed no significant correlations between SSQ bother scores and measures of parental language. Following this, a regression was run looking at the SSQ bother score, with word types as the dependent variable.

There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.841. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10).

	Model 1d		Model 2d	
Variable	B	β	B	β
Constant	127.00		100.45	
WHOQOL-BREF	7.65	0.21	8.39	0.23
SSQ Bother score			1.23	0.14
R^2	0.04		0.06	
F	3.81		2.76	
ΔR^2	0.04		0.02	
ΔF	3.81		1.68	

Table 5-11 SSQ predictor

Abbreviations: SIMD, Scottish Index of Multiple Deprivation; N=87

Model 1d revealed that WHOQOL accounts for 4.3% of the variation in word types. The addition of the sleep and settle bother score to the prediction of total number of word types (Model 2d) led to an increase in R^2 of 0.062. This was not a statistically significant increase $F(1, 84)=1.678$, $p=.199$.

The full model of WHOQOL and sleep and settle bother score to predict total number of word types was $R^2=0.062$, $F(2,84)=2.760$, $p=0.69$, adjusted $R^2=.039$. This model was not found to be significant.

5.8 Discussion

Following the literature discussed both at the beginning of this thesis and the beginning of this chapter, it was predicted that there would be an observed relationship between SES and parental communication. Specifically, we predicted that the language and gesture used by parents when communicating with their infants would be associated with their SIMD rank. We also set out to examine if other parental factors, namely maternal level of education, WHOQOL-BREF scores and SSQ scores would have any influence on parental language and gesture.

5.8.1 SES and parental communication

We found a clear relationship between SES and parental communication. Parents from a higher SES background produced a higher quantity of words, spoke with a more varied vocabulary, and used longer utterances. This finding replicates previous research which has found that mothers from a higher SES spoke more and with a more varied vocabulary than mothers of a lower SES (Hoff, 2003). Moreover, both SES, measured via SIMD, and quality of life, measured via WHOQOL-BREF scores, were correlated with more parental language measures than maternal education. This suggests that deprivation may be having more of an influence on parental language than level of education, and that part of the relationship between parent language and deprivation may be due to quality of life.

Interestingly, SES did not appear related to the gestural output of parents. This could be due to the fact that the parents are communicating with a nonverbal interlocutor, which may have limited the results. It may be that parents in this study gestured in similar ways, as gesturing was seen as an integral factor for interactions with preverbal infants. While some literature suggests SES related differences in the non-verbal communication of parents, these studies were done on 14-20-month-old infants (Iverson et al., 1994; Rowe, 2000). At this point in development infants are verbal and are beginning to form early words (Rowe and Goldin-Meadow, 2009). It may be that parental gestures become more meaningful and specific at this stage of development, and SES related differences become apparent. As our sample was only 9-months old, the way in which parents are interacting with their infants is inevitably different to how they would interact with an older child who is more advanced in terms of joint attention and early language. It may be that parents in this study gestured in similar ways, as gesture was seen as an important component of interactions with preverbal infants.

Regression analysis revealed that SIMD predicted variation in parental MLU more substantively than word types and word tokens. Moreover, the addition of WHOQOL-BREF scores and maternal level of education did not significantly improve the model for any outcome measure. From this, it appears as though parental MLU is the language outcome best predicted by SES and that SIMD has more of an effect on parent language compared to quality of life measures (WHOQOL-BREF) or level of education. This is similar to other studies which have found parental MLU to be influenced by SES (Hoff, 2003).

5.8.2 Maternal education and parental communication

The results of this study also indicated a positive correlation between maternal education and MLU. This is similar to what has been shown in the literature, wherein mothers with a higher level of education produced longer utterances when communicating with their infants (Rowe, 2008). Taken together, these results have important implications in terms of the language risk experienced by children of low SES households. Researchers have long suggested that the language environment plays a critical role in individual language development (Hart and Risley, 1995). Moreover, SES related differences in language exposure are consistently reported (Hoff, 2003). This study adds to this body of literature by showing that SES has an important influence on the language used by parents when communicating with their infants, as early as 9 months of age. Moreover, given the stronger effect of SIMD on parental language compared to maternal level of education, this suggests that parental communication is more affected by deprivation circumstances than education level.

5.8.3 WHOQOL-BREF and SSQ and parental communication

WHOQOL-BREF scores were also found to be related to parental language and gesture, with WHOQOL-BREF positively correlating with manipulating infant, word types, word tokens and MLU. Given that the positive correlation with manipulating infant is the only gesture score that correlated with a familial factor, it is reasonable to assume that this was a random correlation. Subsequently, it will not be discussed any further. From the regression analysis, we observed that WHOQOL-BREF scores only accounted for a small amount of the variability of word types, and the addition of SSQ bother scores did not add a significant increase. Although there is a positive correlation between parental communication and WHOQOL-BREF scores, given the high correlation between SIMD and WHOQOL-BREF scores, it is possible that the relationship between WHOQOL-BREF and parent language is occluded by the strong relationship between SIMD and WHOQOL-BREF, and SIMD and parental language.

While it does exhibit good psychometric properties, the WHOQOL-BREF is a generic measure of quality of life (The Whoqol Group, 1998). For the purposes of this study, it could be that the WHOQOL-BREF lacked the specificity to detect any language specific effects. While the WHOQOL-BREF may be a robust measure to detect the perceived quality of life across participants, it appears as though it is not particularly related to subsequent parental language production. Moreover, although there is evidence suggesting that mothers experiencing depression may be less able to support their infant's language learning, the WHOQOL-BREF is not a clinical based measure of depression and we are unable to ascertain from the available results if any of our parents experienced depression and consequent changes in their language output (Sohr-Preston and Scaramella, 2006).

For our final set of analysis, we chose to include the SSQ scores. We hypothesized that parents experiencing high scores on the bothered with sleep scale may exhibit changes in their language output, specifically that they may exhibit lower volume of word types. The SSQ scores did not make a significant increase above the WHOQOL alone, in the variability of produced word types. This is not necessarily surprising given the overlap between both measures. The WHOQOL measures sleep and rest as part of the physical health domain questions, while the SSQ focuses specifically on infant sleep patterns through parent report (Matthey, 2001; The Whoqol Group, 1998). The lack of a significant increase through the addition of SSQ scores to WHOQOL in the variability of parental vocabulary, measured in word types, could be due to an overlap of interest between the measures. Moreover, neither the SSQ nor the WHOQOL-BREF were specifically focused on measures of language.

From the analysis in this chapter it is clear that deprivation is having an effect on the way in which parents communicate with their infants. In our sample, infants from higher SES homes had parents who communicated with more words, richer vocabularies and produced longer utterances. There is significant evidence that suggests that this difference in language environment may have serious implications for later language outcomes.

6 Influences on infant language outcomes at 24 months

6.1 Outline

In chapters 1 and 2 I showed how SES and prematurity influence child language outcomes. In chapters 4 and 5 I looked at how parental communication was influenced by prematurity (chapter 4) and socioeconomic status (chapter 5). Following from the work set out previously in this thesis, in this chapter I will focus on how parental communication influences infant language. Specifically, I will look at how different aspects of parental communication relate to different aspects of child communication in the context of variability in SES and early life experience (i.e. gestational age), see figure 6-1.

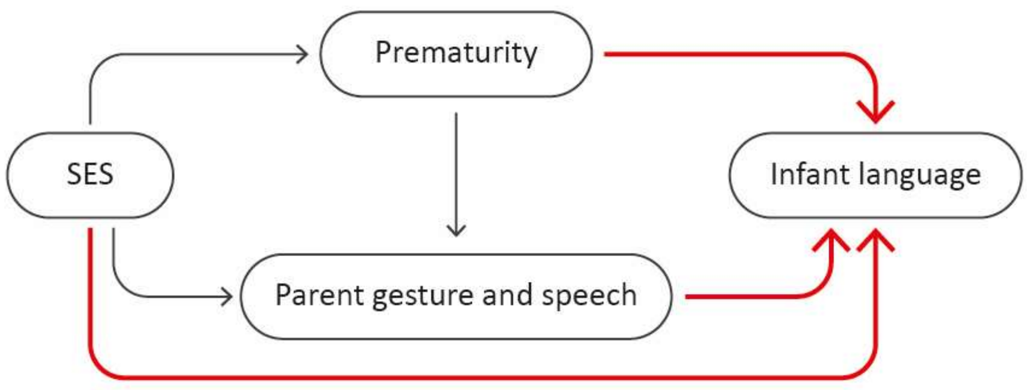

Figure 6-1 Relationship of interest: SES, parent gesture and speech, prematurity and infant language

6.2 Introduction

As discussed in chapter 2, both prematurity and low SES are risk factors for poor infant language development (Cattani et al., 2010; Hart and Risley, 1995). Children from a low SES household display an increased risk for delayed language development (Hoff and Tian, 2005). Additionally, studies have determined that mothers from low SES households speak less and with shorter utterances when communicating with their infants, which may explain the mechanism of this risk factor (Hart and Risley, 1995; Hoff and Tian, 2005). Research suggests that the volume of speech children experience directly infleunces their language development, meaning that the observed SES effect on children's language development may be occuring as a consquence of differences in maternal speech (Hoff and Tian, 2005). In chapter 5 I found evidence in support of this within our sample, as SES was related to parental language production but not gesture production. An important question to then ask is what aspects of maternal speech are having the grestest influence. While it is widely accepted that volume of language input is important for infant language development, researchers also suggest that the quality of parental langauge should be considered when accounting for later langauge skills (Hirsh-Pasek et al., 2015).

6.2.1 Quantity of parent language input

Hoff and colleagues studied 63 mother and child dyads; 33 from high SES backgrounds and 30 from mid SES backgrounds (Hoff, 2003). There were observed differences in children's productive vocabulary, with children from low SES homes having a lower production rate. The observed differences in children's productive vocabulary were completely explained by differences in maternal communication, suggesting that the observed SES differences are actually due to differences in exposure to maternal speech. The authors highlight that the mechanism by which this occurs is twofold: the process through which SES influences maternal speech and the process through which maternal speech influences children's language development. Thus, mothers from low SES homes speak less, which in turn causes children from low SES homes to have less developed language skills. Hoff and colleagues suggest that the way in which maternal speech is influencing children's language development is through the language learning environment. Specifically, mothers who speak with longer utterances are providing important language data for their infants. Consequently, infants who heard longer utterances had a faster rate of productive vocabulary growth. It is important to note that this study is limited as it only measured children's language in samples of spontaneous speech, which may not be an accurate measure of their language capabilities (Hoff, 2003). Additionally, there was no low SES group comparison, though the SES related effects observed between mid and high SES groups are suggestive of even bigger deprivation differences that were not able to be observed within the confines of this study (Hoff, 2003).

It appears as though children's language comprehension is also influenced by exposure to maternal speech. Bornstein and colleagues found that maternal word roots and MLU positively related to children's verbal comprehension (Bornstein et al., 1998). Maternal vocabulary during conversation had a direct influence on their child's verbal comprehension, which further adds to the argument that maternal language input has an important relationship with children's later language outcomes. The authors suggest that SES and maternal knowledge of child development affected maternal vocabulary, and that mothers high on both domains were better able to adapt their language to their child's individual language skill, which consequently had an effect on child language learning (Bornstein et al., 1998).

6.2.2 Quality of parental language input

Hirsh-Pasek and colleagues define quality of language as both "diversity and complexity of words and grammar" (Hirsh-Pasek et al., 2015). In their study, Hirsh-Pasek and colleagues compared quality of verbal and non verbal interactions, with quantity of maternal words. They found that quality, specifically language fluency and connectedness, was a higher predictor of later language ability than quantity of maternal words. Thus, they argue that both quantity and quailty of caregiver language is important for later language success (Hirsh-Pasek et al., 2015).

Pan and colleagues found that word types was a stronger predictor of child vocabulary growth than maternal talkativeness (Pan et al., 2005). Moreover, their findings suggest that quantity alone is not the best predictor of children's vocabulary growth, and they suggest that, specifically when examining children from a low SES background, it is important to look at the quality of communication to which they are exposed (Pan et al., 2005). This result is in contrast to other research which has found that the amount of parental language input predicts infant vocabulary (Huttenlocher et al., 1991). It is important to note that these two studies differed on the SES backgrounds of their participants, and the difference in importance of quality vs. quantity observed may be confounded with SES (Rowe, 2012). More recently, Huttenlocher and colleagues found that quantity and diversity of language use were related to SES but that both were highly related (Huttenlocher et al., 2010). Moreover, after controlling for SES, Huttenlocher and colleagues observed that diversity of speech was related to child vocabulary growth, operationalised as child production of word types (Huttenlocher et al., 2010).

There is evidence suggesting that the way in which parents communicate with their infants has a significant impact on later language development (Bornstein et al., 1998). Parent reports of eliciting conversation, teaching through the use of picture cards, and telling stories have all been found to be positively associated with children's language development in a sample of caregivers and children in China (Hoff and Tian, 2005). Weizman and colleagues found that children's vocabulary at 5 years of age was strongly associated with early exposure to a high volume of sophisticated words and the number of constructive or helpful interactions with their mother (Weizman and Snow, 2001). Sophisticated words were defined as any word that existed beyond the 3,000 most commonly used English words. Thus the authors argue that both the quantity and quality of language a child experiences has important developmental consequences, but that, on top of that, the sophistication of language may have an important developmental role (Weizman and Snow, 2001).

Rowe and colleagues found that different facets of parental language input were important at different points throughout a child's development. Namely, they determined that quantity is most important during the 2nd year of life, while diversity and sophistication of language is most important during the 3rd year of life. Furthermore, into the 4th year of life, more sophisticated facets of language such as narrative and decontextualised language is paramount (Rowe, 2012). This pattern remained even after controlling for SES.

This effect has been replicated in other studies, which have found that maternal vocabulary richness, in addition to the quanity of language exposure, has an impact on children's language development (Hoff and Naigles, 2002). Maternal word tokens, maternal word types and maternal mean length of utterance have all been found to be predictive of children's later vocabulary (Hoff and Naigles, 2002). Interestingly, in this study, the total frequency of maternal utterances was not found to be related to children's vocabulary development. Additionally, they found that mutual engagement did not have an effect on children's vocabulary. They did however find that lexical richness and syntactic complexity had an effect on children's vocabularies, suggesting that the variability of maternal language is important in and of itself for infant language development (Hoff and Naigles, 2002). Interestingly, they did not find that mutual engagement between mother and child had significant influence on children's vocabulary development.

6.2.3 Parental gestural input

In addition to parental language input, it is worth examining parental gesture input. From chapter 2 we know that children use gesture prior to the onset to speech, and that gesture can predict children's later vocabulary (Bates, 1976). Moreover, we established that there is a relationship between parental gesture and children's gestural output (Rowe et al., 2008). Rowe and Goldin-Meadow found that parent gesture predicted child gesture at 14 months, but that parent word types did not relate to child word types at 14 months, or child gesture types (Rowe and Goldin-Meadow, 2009). SES was related to both child and parent gesture at 14 months, indicating that SES had early effects in how both parents and children used gesture. While SES was found to relate to parent word types, it did not relate to child word types. The authors highlight that this suggests that children from low SES are using gesture to communicate fewer meanings than children from high SES. Moreover, these early differences in gesture may offer insight into the later vocabulary differences observed between high and low SES children. Rowe and Goldin-Meadow argue that children from low SES households are expressing less meaning through gesture because they are being exposed to a narrower range of gestures.

This mirrors the arugment above, that children from high SES homes are exposed to a less varied vocabulary which thus impacts their own vocabulary growth (Rowe and Goldin-Meadow, 2009).

Gilkerson and colleagues found that conversational turn count between 18-24 months, which was used as a measure to quantify adult-child alternations, predicted verbal comprehension, and expressive and receptive language skills at 9-13 years old. This remained significant even after controlling for SES or child language development. The authors suggest that this is strong evidence for the important and long-lasting impact that early interaction has on long term developmental outcomes (Gilkerson et al., 2018). Specifically, that input and experiences during a potentially narrow early developmental window can have long lasting implications. This also calls into focus the experience of preterm infants, whose very early experiences are distinct from infants born at term.

6.2.4 *Parental influence and prematurity*

While it is clear that parental influence plays an important role in the language development of children, this effect becomes even more salient when examining a population at risk of language impairment, such as preterm infants. In chapters 1 and 2, I showed that preterm infants are more at risk of language delay, with gestational age strongly associated with outcome. If this relationship is mediated by parent communication, then parental language and gesture becomes an important modifiable risk factor.

Sentenac and colleagues examined the language of 2741 children born between 22 and 31+6 weeks gestation (Sentenac et al., 2020). They found that 42% of children born very preterm had expressive language delay. There was a higher risk of expressive language delay in children who had mothers with lower educational attainment. There was also an increased risk of expressive language delay in children with higher perinatal risk, here defined as lower gestational age and/or severe neonatal morbidity. Very preterm children with mothers who had the lower educational levels had the highest rates of expressive language delay. The authors suggested that the pathway between maternal education and child language outcomes could be due to differences in the home literacy environment, or levels of parental stress (Sentenac et al., 2020). From this, it appears as though early experiences, such as exposure to parental language, interact with prematurity factors such as gestational age, to have an effect on infant language outcomes.

Similarly, Foster-Cohen et al (Foster-Cohen et al., 2007) found that very preterm children were more likely to have smaller vocabularies than full term peers. The earlier they were born, the more they exhibited an increased delay in vocabulary. Preterm children also used shorter utterances compared to full term peers. Adjusting for family factors, such as SES, reduced the association between gestational age and language risk, but only by a small amount. The authors suggest that these results indicate that the language risk experienced by children of a lower gestational age remains a concern regardless of socioeconomic factors; suggesting that prematurity may be a risk for language delay independent of parental language or SES (Foster-Cohen et al., 2007). Moreover, preterm infants are overrepresented at the lower end of language scores and it is important to understand why this is (Foster-Cohen et al., 2007). Thus, it is important that we unpack the increased risk of preterm infants from low SES homes to understand if their increased risk is due to prematurity, SES, or a potentially moderating factor between the two such as parental communication.

6.3 This study

In chapter 4 I examined the vocabulary and gesture of parents of preterm and term born infants. I determined that there were no significant differences in the way in which parents from both groups communicated with their infants. In contrast, in chapter 5 I determined that there were observed differences in the way in which parents from high and low SES backgrounds communicated. Specifically, parents from a high SES spoke more often, in longer sentences, and with a more varied vocabulary. As discussed at the beginning of this chapter, there is significant evidence, suggesting that parental language and gesture input has important implications for infant language development. Given the increased risk of language impairment in both the preterm and low SES population, parent communication is an important modifiable factor that may have particular importance to a high-risk group. From this, I decided to examine a subsample of infants with data available at 24 months, to determine if any of the observed group differences discussed in previous chapters had an effect. The analyses in this chapter help to explore whether or not the quality and quantity of parental language and gesture impacts the expressive and receptive language outcomes of infants at 24 months. All of the analyses included in this chapter were exploratory, as it was clear at the outset that the risk of type 2 error was high, given the small sample size available. Only a subset of the original 100 infants were included, as not all eligible infants turned 24 months during the the duration of this PhD project. Nevertheless, nearly half of the original sample were included in this longitudinal study, though this number was furthur limited due to onset of COVID-19 and a subsequent inability to continue data collection.

6.4 Methods

6.4.1 Participants

Data from a total of 43 participants were collected. The term born group consisted of 29 infants born >32 weeks gestation (17 male infants and 12 female infants). The preterm group consisted of 14 infants born <32 weeks gestation (8 male infants and 6 female infants). All participants were recruited as part of the larger TEBC study in which this thesis sits. Data collected from all 43 participants were included in the analysis in this chapter.

Measure		Mean	Standard Deviation	MIN	MAX	Skew	Kurtosis
SIMD 2016 rank	Preterm (n=14)	4817	1924	1388	6863	-.65	-.92
	Term (n=28)	4685	1940	727	6936	-.86	-.53
Gestational age at birth/ weeks	Preterm (n=14)	28.64	1.60	26	31	.03	-1.16
	Term (n=29)	39	1	4	41	-.23	.55

Table 6-1 Participant Descriptives

Descriptive statistics on SIMD rank and gestational age at birth were produced for all 43 participants, see table 6-1. SIMD rank for the control group had a mean of 4685 (SD=1940) and 4817 (SD=1924) for the preterm group. No significant difference was found between the SIMD rank of preterms or controls $t(40)=-.208$, p=836). Gestational age at birth for the control group had a mean of 39 (SD=1) and 28.64 (SD=1.598) for the preterm group.

6.4.2 Design

This study was a between-subjects, longitudinal design. The independent variables were parental SIMD rank, gestational age at birth, total number of parental gesture, frequency of parental pointing, parental MLU. Dependent variables consisted of a range of measures of infant language outcomes at 24 months. These included scores on the MacArthur-Bates Communicative Development Inventories words and sentences words produced scale, the MacArthur-Bates Communicative Development Inventories words and sentences MLU scale, the Vineland Adaptive Behaviour Scale Parent/Caregiver Rating form receptive raw score, and the Vineland Adaptive Behaviour Scale Parent/Caregiver Rating form expressive raw scores.

6.4.3 Materials

6.4.3.1 SES

SES was measured using the SIMD 2016 (Scottish Government, 2016). As discussed in chapter 1.3.1, the SIMD is a multiple measure tool used by the Scottish government to rank small areas, referred to as data zones, from most deprived to least deprived (Scottish Government, 2016). The SIMD splits Scotland into 6,976 data zones all with similar population sizes. These data zones are then examined for multiple indicators of deprivation, which are then are grouped into seven domains (employment, income, crime, housing, health, education, access), which are finally grouped into one SIMD. This results in each data zone in Scotland being ranked from 1 (most deprived) to 6,976 (least deprived), (Scottish Government, 2016). SIMD scores were therefore collected based on the participants' self-reported postal code.

6.4.3.2 Gestational age at birth

Information regarding gestational age was recorded by an NHS provider using Maternity Trak at birth. This information was retrieved from RedCap by the author of this thesis.

6.4.3.3 Parent language and gesture scores

Parent language and gesture scores were collected from the 9-month data collection time point and were the same as described in chapters 4 and 5. Parent-child play videos were coded for parental language and gesture as per the coding scheme described in chapter 3. Parent gesture and language scores were stored on a secure University of Edinburgh computer.

6.4.3.4 MacArthur-Bates Communicative Development Inventories-Words and Sentences (MCDI-WS)

Parents were provided with the MacArthur-Bates Communicative Development Inventories-Words and Sentences, herein referred to as the MCDI-WS, prior to their 24-month appointment and asked to bring the completed questionnaire to the appointment. The MCDI-WS is designed for use with children between the ages of 16-30 months (Foster-Cohen et al., 2007). It contains measures of expressive vocabulary, grammatical complexity, language structures and morphemes currently in use, and children's longest MLU. The vocabulary checklist is a production checklist where parents are asked to select all words used by their child. It contains 22 semantic categories, with eleven of those consisting specifically of nouns. Internal consistency on the MCDI WS has a Cronbach's alpha of .96 for words produced. Test-retest correlations have correlations above .90. The MCDI WS is considered to have high levels of validity (Fenson, 2002). Scores on the MCDI-WS were tabulated according to the test manual (Fenson, 2002). All data was then securely entered and stored in RedCap.

For this study, I used the MCDI-WS vocabulary production measure and longest MLU measure. I specifically did not use the more complex grammatical measures, such as the measure of spatial and temporal decontextualisation of language, as my primary focus was on general language abilities, rather than more complex syntactical development. Moreover, as we had a small sample at 24 months, who had limited scores on the more complex measures, I decided to focus on more general language development measures to try and allow for the most variability of scores possible.

6.4.3.5 Vineland (VABS)

Prior to the 24-month appointment, parents were asked to complete the Vineland Adaptive Behaviour Scale Parent/Caregiver Rating Form, herein referred to as VABS. The VABS is a standardized assessment tool that measures adaptive behaviour and is used to support the diagnosis of developmental delays (Pepperdine and McCrimmon, 2018). There are 11 domains, and items in each domain are placed in developmental order and rated on a scale from 0 (never), 1 (sometimes) or 2 (usually or often). Some items require a yes (scored as 2) or no (scored as 0) response. It can be used for ages 0 to 90+ and asks questions about home and family-life behaviour. It contains 502 items, but only the 88 items from the "listening and understanding" and "talking" sections within the communication domain are used in the analysis in this chapter. The VABS is found to have good internal consistency with coefficient alpha's ranging from .86 to .99. Test retest reliability is high with r values ranging from .62 to .92. The VABS Parent/Caregiver form has moderate to high correlations with other measures of behaviour (Pepperdine and McCrimmon, 2018).

6.5 Procedure

Participants were consented into the TEBC as outlined in chapter 3. Data for this chapter was collected as a part of the 24-month appointment as outlined in chapter 3. Data included in this chapter includes demographic information collected at birth, questionnaire data from the 24-month appointment, and coded videos collected at the 9-month appointment.

Approximately two weeks prior to their appointment, parents were asked to complete a series of questionnaires including the MCDI-WS and the VABS. A full list of questionnaires included at this time point can be seen in chapter 3. These questionnaires were collected at the appointment by a member of the research team.

Following the appointment, the MCDI-WS and VABS were scored by members of the research team using the scoring instructions in the manual for the MCDI and Vineland (Fenson et al., 2000). Corrected gestational age was used for all preterm infants, as is standard practice within the preterm research community (Committee on Fetus and Newborn, 2004). All data was entered into RedCap and the paper copies of questionnaires were stored in a secure filing cabinet in Kennedy Towers in Edinburgh, within the Department of Psychiatry.

6.6 Analysis methods

All analysis was done using SPSS 24. The independent variables were parental SIMD rank, gestational age at birth, total number of parental gestures, frequency of parental pointing, and parental MLU. Dependent variables included infant language outcomes at 24 months. These included scores on the MCDI-WS words produced scale, MCDI-WS MLU scale, Vineland Receptive score, and Vineland Expressive scores. Baseline stats were reported including mean, standard deviations, and medians for infant language outcomes including MCDI-WS words produced score, MCDI-WS MLU score, VABS receptive score, and VABS expressive score.

Descriptive statistics were used to check the normality of the data. Data are considered to have departed from normality if they have a skew value of >2.1 and a kurtosis value of >7.1 (Kim, 2013). Homogeneity of variance was assessed using Levene's test for equality of variances. Data are continuous, randomly sampled and reasonably large, which accounts for all other necessary data assumptions.

A Pearson's correlation was used to investigate correlations between infant language outcomes, and parental and prematurity measures including SIMD, gestational age at birth, parental MLU, total number of parental gesture and frequency of parental pointing. Histograms were created to examine the variability of scores on all available 24-month language measures. Following this, a series of hierarchical regressions was used to determine the predictive capabilities of each of the variables of interest. Variables of interest were selected and inputted based on evidence supported by the literature.

The first regression involved MCDI-WS words produced as the dependent, with total parental gesture, parental MLU and parental pointing as the predictors. This was run to see if parental language and gesture accounted for any of the variability of infant language output. MCDI-WS was chosen as the outcome measure as it is a reliable and commonly used measure for infant vocabulary output (Foster-Cohen et al., 2007). A second regression was run to see if the addition of SIMD improved the prediction of 24 month MCDI-WS words produced scores over and above parental communication (parental MLU, total gesture) alone. The third regression addressed prematurity, and determined whether the addition of gestational age at birth improved the prediction of 24 month MCDI-WS words produced scores over and above parental communication (MLU, total gesture) alone. Having looked at the effect of parental communication on infant vocabulary (MCDI words produced), we then looked at the effect on infant MLU. Thus, a hierarchical regression was run to determine if the addition of SIMD improved the prediction of MCDI MLU scores over and above parental communication (parental MLU, total gesture) alone. We then decided to examine any parental influence on infant language measured by the VABS expressive scores. A hierarchical regression was used to determine whether the addition of SIMD improved the prediction of VABS expressive scores over and above parental communication (MLU, total gesture) alone. This regression was followed by a final hierarchical regression, to determine if the addition of SIMD improved the prediction of VABS receptive scores over and above parental communication (MLU, total gesture) alone.

Subsequently, the group with the lowest language scores at 24 months were further examined to provide a clearer description of the low language group. As this was not a large sample, especially in the preterm group, we did not do significance testing and instead focused on providing a descriptive picture of those infants that scored less than one standard deviation from the mean on at least 3 out of the 4 language measures.

6.7 Results

See table 6-2 for descriptive information on parental gesture and language input in both the preterm and term born group.

Measure		Mean	Standard Deviation	MIN	MAX	Skew	Kurtosis
Total parental gesture	Preterm (n=14)	182.57	47.37	91	265	.08	.25
	Term (n=29)	194.21	46.05	104	285	.17	-.82
Frequency of parental pointing gesture	Preterm (n=14)	6.86	6.63	0	25	1.80	3.58
	Term (n=29)	8.72	6.64	0	22	.78	-.55
Parental MLU	Preterm (n=14)	3.50	.49	1.41	2.82	-.02	-1.41
	Term (n=29)	3.23	.58	2.10	4.40	.08	-.29
Total number of parental word types	Preterm (n=14)	183.07	55.51	65	262	-.61	.13
	Term (n=29)	177.07	52.30	52	294	-.24	.91

Table 6-2 Descriptives of parental communication for 24 month participants (n=43)

6.7.1 Group differences

An independent t-test was used to determine if any observed differences in the language outcomes at 24 months of term born and preterm born infants were significant. As before, there was homogeneity of variances for all scores as assessed by Levene's test for equality of variances. See table 6-3 for the group descriptive statistics on language outcome measures.

	Term			Preterm		
Code	N	Mean	St.Dev	N	Mean	St.Dev
MCDI words produced	28	195.50	131.78	14	179.43	95.02
MCDI MLU	28	3.12	2.57	14	3.5	2.61
Vineland Receptive	26	46.88	11.20	12	44.58	6.24
Vineland Expressive	26	40.50	15.57	12	39.25	13.06

Table 6-3 Descriptive statistics for infant language scores at 24 months

No significant differences between preterm and term scores were found on the MCDI-WS words produced ($t(40)=.406$, $p=.687$), MCDI-WS MLU ($t(40)=-.448$, $p=.657$), Vineland Receptive ($t(36)=.663$, $p=.512$) or Vineland Expressive ($t(36)=.241$, $p=.811$).

6.7.2 Correlational analysis including infant language outcomes, parental communication, gestational age, and SES

		MCDI 24 months words produced	MCDI 24 months MLU	Raw Vineland Receptive	Raw Vineland Expressive
Total number of parental gesture	Pearson Correlation	-.163	-.018	.056	-.106
	Sig. (2-tailed)	.302	.911	.739	.527
	N	42	42	38	38
Frequency of parental pointing	Pearson Correlation	-.220	-.133	-.068	-.100
	Sig. (2-tailed)	.162	.401	.686	.549
	N	42	42	38	38
Parental MLU	Pearson Correlation	-.016	.112	-.250	-.094
	Sig. (2-tailed)	.919	.481	.129	.576
	N	42	42	38	38
Parental total word types	Pearson Correlation	-.037	-.089	-.142	-.126
	Sig. (2-tailed)	.817	.577	.394	.453
	N	42	42	38	38
SIMD Rank	Pearson Correlation	.065	.082	-.134	.063
	Sig. (2-tailed)	.688	.609	.431	.710
	N	41	41	37	37
Gestation of pregnancy at birth	Pearson Correlation	.071	-.085	.121	.016
	Sig. (2-tailed)	.657	.591	.471	.924
	N	42	42	38	38

Table 6-4 Correlational matrix of infant language outcomes and prematurity, SES, and parental communication factors

No significant correlations were apparent when examining our candidate predictors and infant language outcomes. Given the low power, it is worth considering whether any pearson coefficients reveal relations of potential future interest. There is a small negative association between parental pointing and MCDI words produced (r=-.220), and a small negative association between parental MLU and Vineland receptive scores (r=-.250). However, given the small strength of the associations, and a lack of significance, they will not be discussed further.

6.7.3 Histograms of infant language outcomes

In order to assess which language outcome measure would provide the most variability for our regressions, histograms were created for each of the four measures of infant language at 24 months (MCDI-WS words produced, MCDI-WS MLU, Vineland Expressive and Vineland Receptive scores). See figure 6-2 for the histograms of 24-month language scores for all participants.

<table>
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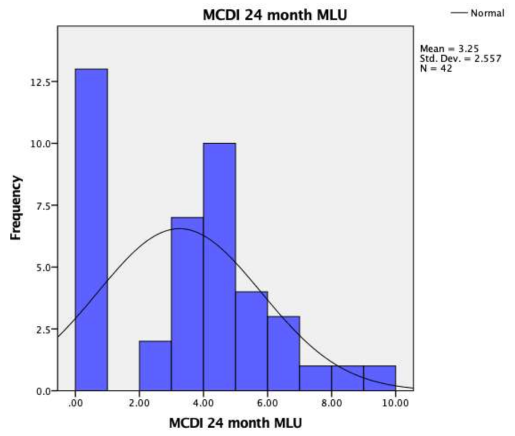
<td>
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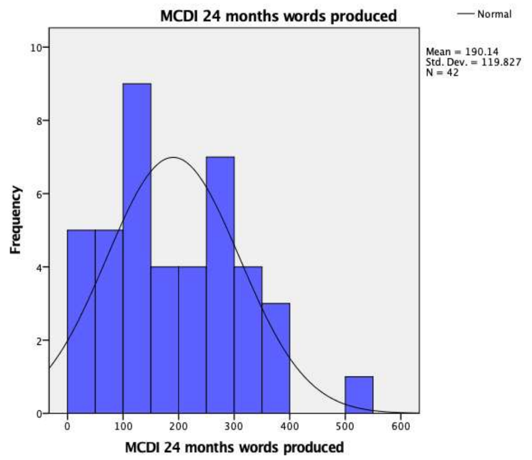
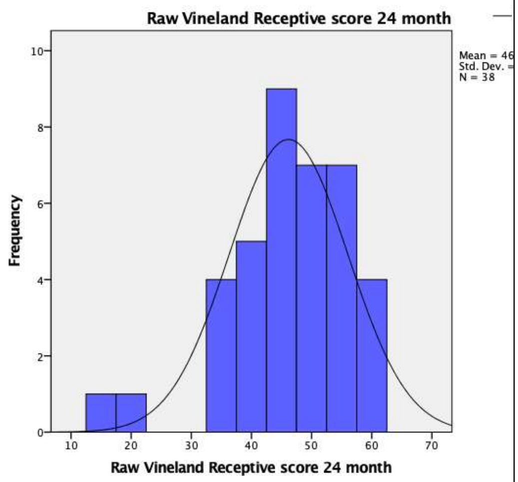
<td>
</td>
</tr>
<tr>
<td>Figure 6-2a MCDI 24 month MLU score</td>
<td>Figure 6-2b MCDI 24 months word produced score</td>
</tr>
<tr>
<td>
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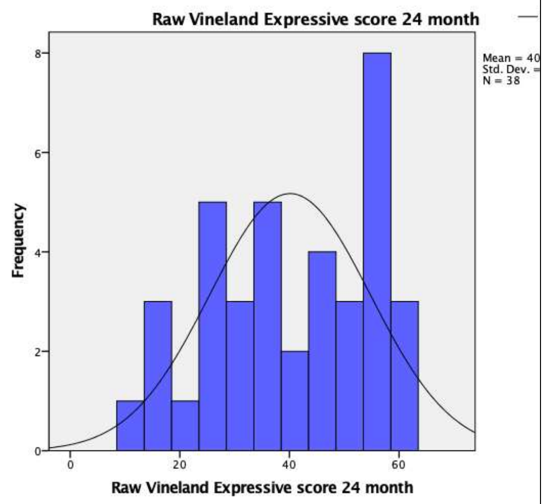
<td>
</td>
</tr>
<tr>
<td>Figure 6-2c Vineland Receptive score</td>
<td>Figure 6-2d Vineland Expressive score</td>
</tr>
</table>

Figure 6-2 24-month language scores histograms

Visual inspection of the histograms revealed that variability in scores was similar across measures. Thus, going forward, all measures were included in the regressions.

6.7.4 Regressions

Following the results of the correlational analysis, a series of hierarchical regressions were run to verify if there were any nonlinear relationships between variables (Shmueli, 2010). The variables chosen for the following regressions were selected based on a theoretical model developed from the literature as opposed to a statistical model based on previous analyses.

6.7.4.1 Regression 1- MCDI-WS words produced dependent.

Model 1a revealed that parental total gesture, MLU and pointing accounts for 8.3% of the variation in 24 month MCDI words produced scores, see table 6-5. This was not a significant predictor. The full model of parental communication factors (frequency of pointing gesture, total number of gesture, parental MLU) to predict 24 month MCDI Words produced scores was R^2 = .083, $F(3,38)$ =1.149, p = .342, adjusted R^2 = .011. This was not found to be significant. There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.831. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.038.

	Model 1a	
Variable	B	β
Constant	285.76	
Total gesture	-0.48	-0.19
MLU	9.46	0.04
Pointing	-4.41	-0.24
R^2	.08	
F	1.14	
ΔR^2	.083	
ΔF	1.15	

Table 6-5 Regression MCDI Words produced dependent

6.7.4.2 Regression 2- MCDI-WS Words Produced Dependent

As before, there was independence of residuals, as assessed by a Durbin-Watson statistic of 1.995. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.0964.

Model 1b revealed that parental total gesture and parental MLU alone accounts for 2.7% of variation in 24 month MCDI words produced scores, see table 6-6. This was not a significant predictor. The addition of SIMD to the prediction of 24 month MCDI Words produced (Model 2b) led to an increase in R^2 of 0.045. This was not a statistically significant increase $F(1, 37) = .706$, $p = .406$. The full model of parental communication factors and SIMD to predict 24 month MCDI Word production scores was $R^2 = .045$, $F(3,37) = .587$, $p = .627$, adjusted $R^2 = -.032$.

	Model 1b		Model 2b	
Variable	B	β	B	β
Constant	323.732		331.512	
Total gesture	-0.308	-0.123	-0.344	-0.137
MLU	-21.234	-0.097	-34.350	-0.157
SIMD			0.009	0.149
R^2	0.027		0.045	
F	.532		.587	
ΔR^2	0.027		0.018	
ΔF	.532		.706	

Table 6-6 Regression MCDI-WS Words produced dependent (SIMD predictor)

6.7.4.3 Regression 3- MCDI-WS Words Produced Dependent

There was independence of residuals, as assessed by a Durbin-Watson statistic of 1.893. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.0404.

Model 1c revealed that total parental gesture and parental MLU alone accounts for 2.7% of variation in 24 month MCDI words produced scores, see table 6-7. This was not a significant predictor. The addition of gestational age at birth to the prediction of 24 month MCDI-WS words produced (Model 2c) led to an increase in R^2 of 0.033.

This was not a statistically significant increase $F(1, 38)$ =.261, p =.613. The full model of parental communication factors and gestational age at birth to predict 24 month MCDI-WS words produced scores was R^2 = .033, $F(3,38)$ = .436, p = .728, adjusted R^2 = -.043.

	Model 1c		Model 2c	
Variable	B	β	B	β
Constant	273.79		188.48	
Total gesture	-0.42	-0.16	-0.43	-0.17
MLU	-1.32	-0.01	3.86	0.02
Gestation at birth			2.00	0.09
R^2	.027		.03	
F	.53		.44	
ΔR^2	.027		.01	
ΔF	.53		.26	

Table 6-7 MCDI-Words produced dependent (Gestational age predictor)

6.7.4.4 Regression 4- MCDI-WS MLU Dependent

Again, there was independence of residuals, as assessed by a Durbin-Watson statistic of 1.688. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.0964

Model 1d revealed that parental total gesture and parent MLU accounted for 0.2% of 24 month MCDI MLU scores, see table 6-8. This was not a significant predictor. The addition of SIMD to the prediction of MCDI-WS MLU produced (Model 2d) led to an increase in R^2 of 0.007. This was not a statistically significant increase $F(1, 37)$ =.176, p =.677. The full model of parental communication factors and SIMD to predict MCDI-WS MLU was R^2 = .007, $F(3,37)$ = .087, p = .967, adjusted R^2 = -.074.

	Model 1d		Model 2d	
Variable	B	β	B	β
Constant	2.54		2.63	
Total gesture	0.00	0.01	0.00	-0.00
MLU	0.22	0.05	0.08	0.02
SIMD rank			0.00	0.08
R^2	.00		0.01	
F	.04		.09	
ΔR^2	.00		.01	
ΔF	.04		.18	

Table 6-8 MCDI-WS MLU dependent

6.7.4.5 Regression 5- VABS Expressive

Again, there was independence of residuals, as assessed by a Durbin-Watson statistic of 2.131. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.1116.

In Model 1e parental total gesture and parental MLU accounted for 5.6% of 24 month VABS expressive scores, see table 6-9. This was not a significant predictor. The addition of SIMD to the prediction of Vineland expressive scores (Model 2e) led to an increase in R^2 of 0.083. This was not a statistically significant increase $F(1,32)$ =.958, p=.335. The full model of parental communication factors and SIMD to predict Vineland expressive scores was R^2 = .083, $F(3,32)$ = .967, p = .420, adjusted R^2 = -.003.

	Model 1e		Model 2e	
Variable	B	β	B	β
Constant	62.79		63.53	
Total gesture	-0.02	-0.05	-0.02	-0.06
MLU	-5.71	-0.22	-7.69	-0.30
SIMD rank			0.00	0.18
R^2	.056		.08	
F	.97		.97	
ΔR^2	.056		.03	
ΔF	.97		.96	

Table 6-9 VABS expressive dependent

6.7.4.6 Regression 6- VABS Receptive dependent

Again, there was independence of residuals, as assessed by a Durbin-Watson statistic of 2.334. There was no evidence of multicollinearity, as assessed by tolerance values greater than 0.2. Tests to see if the data met the assumption of collinearity indicated that multicollinearity was not a concern (VIF <10), average VIF is 1.1116.

Parental MLU and parental total gesture accounted for 11.7% of the variability of infant VABS receptive scores (Model 1f), see table 6-10. This was not a significant predictor. The addition of SIMD to the prediction of Vineland receptive scores produced (Model 2d) led to an increase in R^2 of .117. This was not a statistically significant increase $F(1,32)$ =.014 p =.960. The full model of parental communication factors and SIMD to predict Vineland receptive scores was R^2 = .117, $F(3,32)$ = 1.416, p = .256, adjusted R^2 = .034.

	Model 1f		Model 2f	
Variable	B	β	B	β
Constant	61.89		61.83	
Total gesture	0.03	0.11	0.03	0.11
MLU	-6.18	-0.34	-6.01	-0.33
SIMD rank			0.00	-0.02
R^2	.117		.117	
F	2.18		1.42	
ΔR^2	.117		.00	
ΔF	2.18		.01	

Table 6-10 VABS receptive dependent

6.7.4.7 Low language scorers

Out of 43 participants, 4 scored at least one standard deviation below the mean on at least 3 out of 4 language measures. Three out of four of the low language group had low scores on the MCDI-WS words produced, MCDI-WS MLU, and VABS expressive. Only one participant also scored below one standard deviation from the mean on the VABS receptive. See table 6-11 for demographic information on the low language group. See figures 6-3 to 6-8 for more descriptive information on this sample.

Participant	Gender	Preterm	Feeding	SIMD
8001	M	Yes	Formula	1388
8036	M	No	Mixed	Data missing
8104	F	No	Breast	5480
8111	F	No	Breast	4758

Table 6-11 Gender, prematurity, SES, and feeding information on low language group

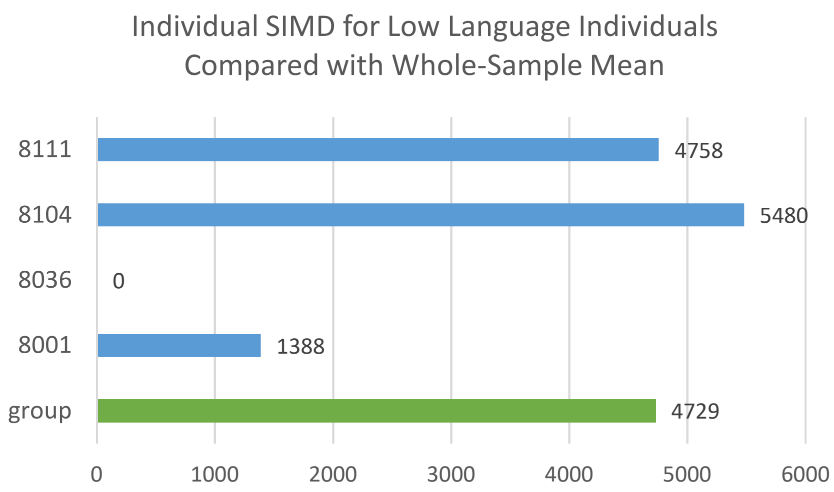


Figure 6-3 Individual SIMD scores compared with whole-sample mean

While the average SIMD rank for the low language group (3875) was lower than the average for the whole sample (4729), only one child in the low language group was from a low SES, see figure 6-3. Similarly, only one child in the low language group was born preterm, see figure 6-4.

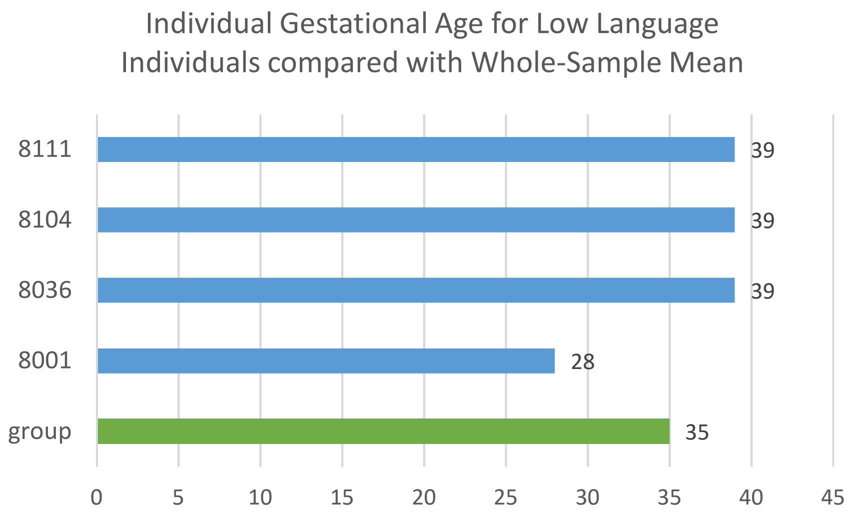


Figure 6-4 Individual gestational age compared to whole sample mean

In terms of parental communication, parents of children in the low language group displayed similar rates of word types and MLU compared to the group mean, see figures 6-5 and 6-6. This suggests that, on average, infants in the low language scoring group did not experience significantly reduced parental language.

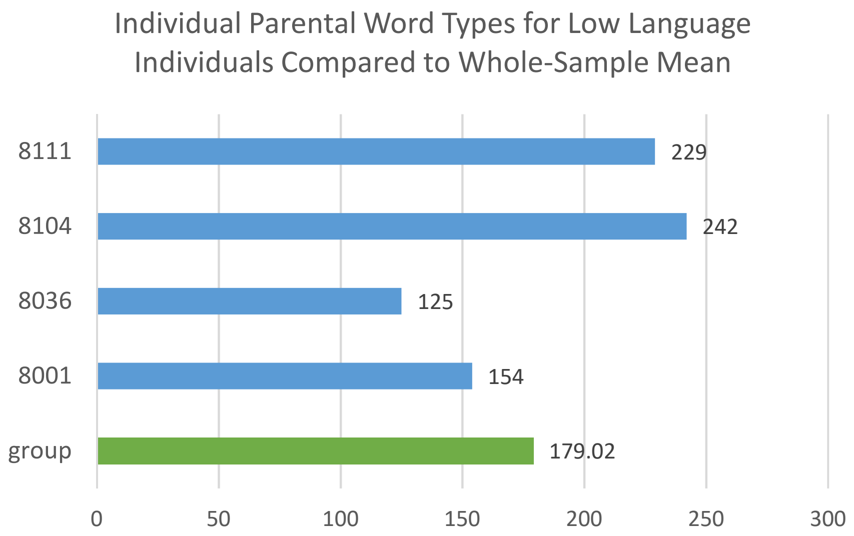


Figure 6-5 Individual parental word types compared to whole sample mean

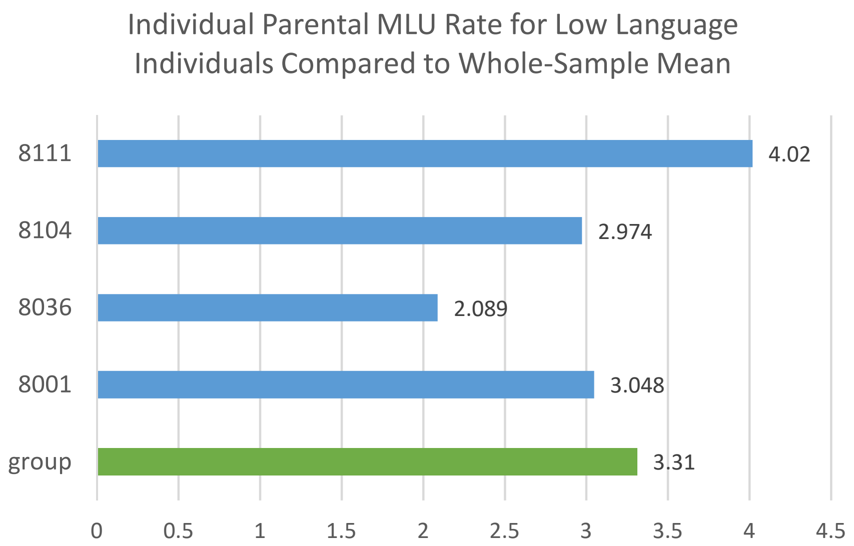


Figure 6-6 Individual parental MLU compared to whole sample mean

In terms of total gesture, parents of the low language group displayed slightly higher rates overall compared to the overall mean. If we discount that gesture use impedes infant language, then this suggests that higher gesture might reflect a responsive parent communication style that is providing a communication environment tailored to the needs of the infant. See figures 6-7 and 6-8 for more information.

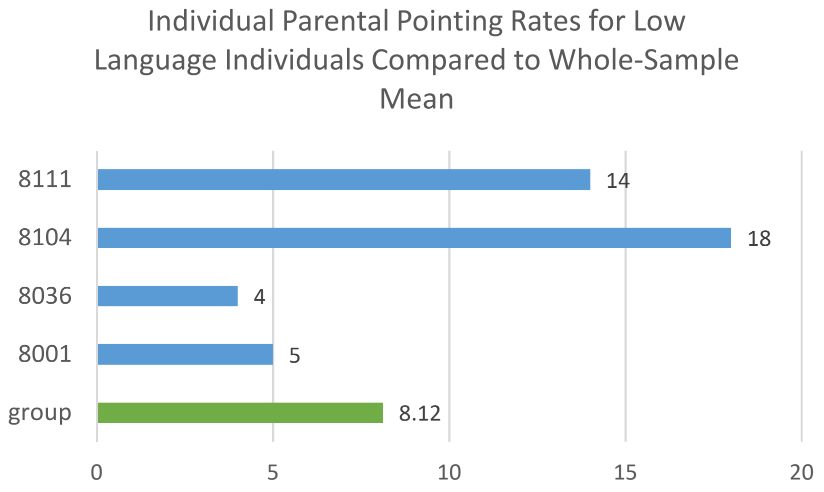


Figure 6-7 Individual parental pointing rates compared to whole sample mean

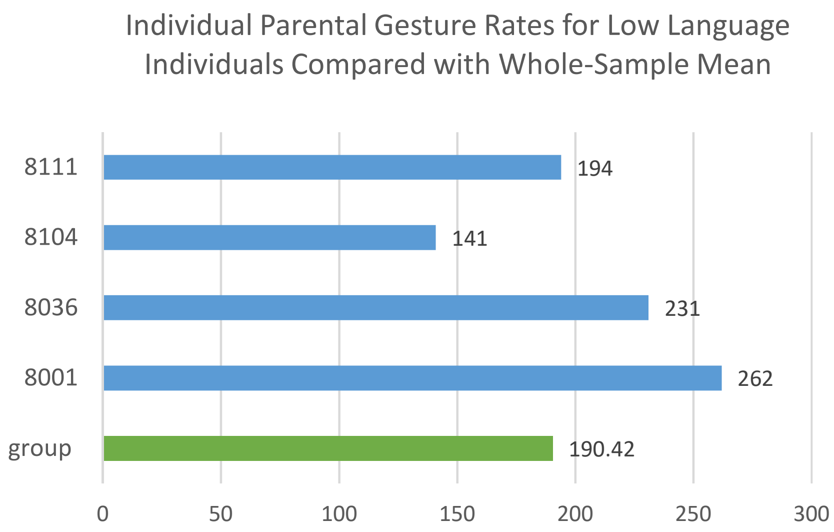


Figure 6-8 Individual parental gesture rates compared to whole sample mean

6.8 Discussion

The analysis undertaken in this chapter aimed to determine whether parental communication at 9-months, SES, or gestational age at birth predicted infant language outcomes at 24 months.

6.8.1 Infant language 24 months

To begin, we compared the language outcomes of preterm and term children and found no significant differences between the groups. Preterm and term children had comparable scores on all four measures of infant language at 24 months including word production and MLU measured by the MCDI-WS, and receptive and expressive language measured by the VABS. This result is in contrast to the literature which shows that preterm infants are at a higher risk for language delay than their term born peers (Woodward et al., 2009). That said, other research has shown that preterm infants have similar vocabulary outputs as term born peers, but that preterm infants are overrepresented in the lower end of scores (Foster-Cohen et al., 2007). Given that we had a small number of preterm infants in our sample, it is difficult to make a robust comparison with the term born group and there may have been differences that we were unable to detect due to the small number of participants.

The observed lack of difference between preterm and term language in our study could possibly be due to the timing of our measurement. It could be that 24 months, or 24 months corrected, may be too early on in the language development process to detect group differences with a small sample size. By measuring at 24 months, we may have selected a time point that was too early to detect any major communication differences, as it is still a very early stage in the language development process. Additionally, our language measures did not address the preverbal and nonverbal communicative behaviours of infants, which may have revealed differences between preterm and term born groups. 24 months is a mixed period of development, with significant variability in language abilities (Bates and

Dick, 2002). However, at 24 months nonverbal communication abilities are often more advanced than verbal abilities (Cusson, 2003) thus a measure capturing gesture development may have revealed group differences that were not adequately captured by using purely verbal based measures. Neither the MCDI-WS nor the VABS at 24 months has any measure of infant gesture, thus we were unable to capture any non-verbal differences between groups. Researchers have suggested that there are important differences in the nonverbal communicative behaviours of preterm infants that can be indicative of later language risk (De Schuymer et al., 2011).

In addition, our analysis focused on simple measures of language development such as vocabulary production and mean length of utterance. A meta-analysis found that, from 3 to 12 years of age, group differences in complex language function increased between preterm and term born children, but there was no significant increase or decrease in differences in simple language function (Spek et al., 2012). The authors suggest that complex language function may be more useful than measures of simple language function when measuring preterm infant language development. While it may be that our focus on simple language functioning may have occluded any preterm and term differences, what is more likely is that our time point for measurement was too early to detect significant differences between the groups. Moreover, a later measurement time point would have allowed for more available scores in complex language functioning, which may yield more informative results.

6.8.2 Predictors of infant language

Despite variability in individual outcomes, once I had established similar overall language outcomes for term and preterm infants, I examined the relationship between infant language outcomes and potentially influential familial factors. Correlational analysis revealed no significant associations between language measures at 24-months and parental language and gesture, SIMD rank, or gestational age at birth. Although this is surprising given the strong literature suggesting the importance of parental language on infant language development, our results may have been limited by a small sample size or, as mentioned above, limitations due to the time of measurement.

Regression analysis revealed that parent language and gesture accounted for only a small amount of variability in infant language measures. Parental total gesture and MLU was not a significant predictor of infant variability on the MCDI-WS words produced measure. Moreover, the addition of SIMD did not significantly increase this prediction. This is surprising given the literature suggesting that SES plays an important role in infant language outcome, and that parental language specifically is the mechanism through which this relationship operates (Hoff, 2003). In addition, parental communication and SIMD did not significantly predict infant MLU. This is surprising given the literature suggesting that infants exposed to longer utterances are more likely to produce longer utterances themselves (Bornstein et al., 1998; Hoff and Naigles, 2002). That said, studies that have found significant relationships between language exposure and children's mean length utterance are typified by wider age ranges (Hoff and Naigles, 2002) and larger sample sizes (Bornstein et al., 1998), which may explain our limited results.

When looking at the effects of prematurity, neither parental communication (MLU and total gesture), nor the addition of gestational age as a predictor was able to significantly predict infant MCDI-WS words produced scores. Again, this result is surprising given the strong literature suggesting a robust relationship between gestational age, SES and later language outcomes, and may be indiciative of a type ll error (Hoff and Tian, 2005; Sentenac et al., 2020).

While still not a significant predictor, parent language and gesture (MLU and total gesture) accounted for more of the variability of infant VABS receptive scores above any other measure. As discussed in chapter 2, receptive language skills develop earlier and faster than expressive language skills, and by 20 months children are able to produce simple phrases but are able to understand a significant adult lexicon (Bates and Dick, 2002). It could be that our sample had more robust receptive language skills than expressive language, and thus the predictive effects of familial factors were more apparent as a result.

6.8.3 Low language group

When examining specifically those children whose language was delayed relative to the whole sample, we found no distinguishing features of this group. There were no apparent differences in SIMD, or parental communication at 9 months. In other words, the low language group came from a similar SES background as the total sample, and was exposed to a similar volume and type of language at 9-months. All but one of the group had average scores on the VABS receptive language measure, suggesting that this low language group was typified by below average expressive language skills but not receptive skills. While it is difficult, given the limited sample size, to make any robust suggestions, it is nevertheless worth noting that even within the lowest of the language scorers in this sample, all but one maintained average receptive language scores.

Given the small sample size of this group, it is difficult to make any claims from these analyses with any degree of confidence. While it could be that there is a factor unaccounted for in our analysis that is predictive of infant language scores, what is more likely is that our limited sample size is clouding results.

7 Discussion

7.1 Aims of investigation

The research in this thesis aimed to further our understanding of the relationship between SES, prematurity and children's language development, by assessing the way parents communicate with their infants at 9 months of age. The first aim of this thesis was to create a novel coding scheme that would allow for the detailed capture of parental language and gesture use when interacting with a preverbal infant. Building on this, the following two aims of this thesis were to examine the use of vocabulary and gesture of parents of preterm and term infants, and parents from high and low SES backgrounds, to test two hypotheses: (i) that prematurity would not affect parental communication; (ii) that communication would be affected by SES. The final aim of this thesis was to explore the relationship between prematurity, SES, and parental communication, and infant language outcomes at 24-months.

These aims and hypotheses were addressed individually in the experimental chapters of this thesis, and will now be summarised thematically. I will then discuss these findings in relation to the strengths and weaknesses of the work presented in this thesis, and the robustness of the results. Finally, I will suggest future directions for research in this particular area of interest.

7.2 Summary of findings

7.2.1 Predictors of infant language outcome

In chapter 6, I compared infant language scores measured at 24-months with gestational age, SIMD, and parent language and gesture at 9-months. No significant relationships between gestational age, prematurity, parental communication, and infant language at 24 months were found. While SIMD and parental communication predicted more of the variability in infant language outcomes than gestational age, neither were found to be significant predictors.

7.2.2 Parental language and prematurity

Through the use of my novel coding scheme, in chapter 4 I showed that parents of preterm and term children communicated with their 9-month-old infants in similar ways. They used a similar quantity and quality of language, and both groups interacted with their infants and environment in a homogenous manner. There was no difference in the use of gesture between parents of both groups.

7.2.3 Parental language and SES

Using the same coding scheme as before, in chapter 5 I showed that parents from low SES homes were found to communicate with their 9-month-old infants with less varied language and shorter utterances than parents from high SES homes. Again, there were no significant differences in the gestures used by parents from both groups.

7.2.4 Overlap of SES and prematurity

In chapters 1 and 2 I showed that there is significant overlap between the developmental consequences of prematurity and low SES, specifically within the communication domain. Moreover, in chapter 5 I demonstrated that SES has a direct impact on how parents are communicating with their infants, regardless of prematurity. Given the information on the importance of parental communication in regard to later infant language development, presented throughout this thesis, this is a vital relationship to highlight, specifically in relation to those infants who are both premature and from a low SES household.

7.2.5 Value of gesture

Finally, in chapters 2, 4, and 5, I highlighted the importance of parental gesture and non-verbal communication, which serves as important information for preverbal infants. In chapter 3 I expanded on my novel coding scheme, which stresses the importance of capturing non-verbal parent behaviour and how this can be accurately accomplished through the development of a coding scheme designed with a pre-verbal interlocutor in mind.

7.3 Implications of study findings

7.3.1 Prematurity

While some research suggests that language delay is itself a result of prematurity (Woodward et al., 2009), others suggest that the mechanism through which this relationship operates may not be as straightforward (Wolke et al., 2008). By examining the communication of parents, we were able to assess if preterm infants are being exposed to less language and gesture when interacting with their parents, thereby understanding if differences in language exposure are underlying the observed increase in risk within the preterm population. Our finding that parents of preterm infants use language and gesture in similar volumes and fashion to parents of term infants is in support of the literature (Salerni et al., 2007). Moreover, the results from this study suggest that the increase in language risk observed in the preterm population is likely not due to differences in language output between parents of term and parents of preterm infants, but instead due to some other factor.

Experimental evidence has suggested that language delays in the preterm population may be due to more general cognitive impairment (Wolke et al., 2008), differences in very early language exposure in the NICU (Caskey et al., 2014), or neurological development (Rees and Inder, 2005). It is outside of the scope of this thesis to fully understand the relationship between prematurity and language risk. Nevertheless, the literature also suggests that parental language input can offer important developmental data for infants, and can have a protective effect for infants who are at an increased risk for language difficulties or delay (Huttenlocher et al., 2010; Vernon-Feagans and Bratsch-Hines, 2013). Thus, despite no apparent differences in the language and gesture of parents of preterm vs term infants, parental communication offers an important area for potential intervention for infants at a higher risk of language difficulties. This possibility will be explored in more detail in the latter half of this chapter.

7.3.2 Intersection with SES

In addition, the literature shows that mothers from a low SES background are at an increased risk of preterm delivery, and that preterm infants are overrepresented at the lower end of the SES spectrum (Smith et al., 2007). Studies looking at the language outcomes of preterm infants that do not control for SES may in fact be observing language delays due to deprivation rather than prematurity (Foster-Cohen et al., 2010). Understanding how deprivation can affect parental communication is valuable for a number of reasons. Our study revealed that as early as 9 months of age, infants from lower SES homes are exposed to less parental language, less varied vocabulary and shorter utterances. This language effect is supported by the literature, whereby higher SES mothers have been found to use longer utterances, and have higher volumes of word types and tokens (Hoff, 2003). Researchers have shown that parental language input is vital for children's language development, and that both the quantity and quality of language a child is exposed to influences their own language growth and developmental milestones (Hoff and Naigles, 2002). If a child growing up in a low SES home is exposed to less language, then they are at a potential disadvantage compared to their high SES peers in relation to their linguistic environment. Moreover, preterm children from low SES homes may be experiencing a compounded risk due to both deprivation and their prematurity status, which could have important implications for their language development (Ene et al., 2019).

7.3.3 Quality vs quantity

Researchers have suggested that both the quantity and quality of language exposure is important for children's language development (Hirsh-Pasek et al., 2015; Pan et al., 2005). In the study described in chapter 5, I found that SES was correlated with both the quantity of language, measured via word tokens, and the quality of language, measured via word types. Thus, high SES parents are providing a linguistic environment for their child that contains increases in both exposure and diversity of language, which provides infants with a data rich opportunity for their own language growth and development. This disparity in language environment according to SES is not a new revelation (Hart and Risley, 1995). However, understanding the intersection of prematurity and deprivation, and the potentially compounded risk of infants experiencing both, is an important area of interest and offers many avenues of potential interventions (Ene et al., 2019). Moreover, although the results of these analyses did not reveal any SES related effects on parental gesture, understanding if and how parental nonverbal communication is effected by level of deprivation offers additional areas for possible intervention.

7.3.4 Predictive effects

The lack of significant predictive effects of gestational age, SES, or parental communication on infant language at 24 months is surprising for a number of reasons. Firstly, both prematurity and low SES are known risk factors for adverse language outcomes (Barre et al., 2011; Fernald et al., 2013). Preterm infants are at risk of delays in preverbal skills, such as pointing, as well as later global delays in both expressive and receptive language (Cattani et al., 2010; De Schuymer et al., 2011). In addition, children from low SES homes experience delays in language development, specifically in regards to vocabulary development (Fernald et al., 2013; Pungello et al., 2009). Children from low SES backgrounds also use lower rates of gesture to communicate meaning, which has important later linguistic consequences (Rowe and Goldin-Meadow, 2009). Finally, research has found significant evidence for a relationship between parent language input and infant language development (Iverson et al., 1994; Schmidt and Lawson, 2002; Zammit and Schafer, 2011).

As discussed in chapter 6, this study was limited by a small sample size and an uneven preterm and term split. Nevertheless, we found that gestational age at birth did not have a significantly predictive effect on infant language, but SIMD scores and parental communication were able to account for some of the variability in infant language outcomes at 24 months. Although not statistically significant, this additional evidence compliments what was found in the previous two studies, to suggest that deprivation may have more of a direct impact on infant language outcomes compared to prematurity. This is important, as language risk is often cited in the literature as being a major risk associated with prematurity (Cattani et al., 2010). The new evidence presented in this thesis suggests that deprivation, rather than prematurity, may be posing the biggest influence of language risk. Moreover, given the increased propensity for preterm birth within the low SES demographic, infants born prematurely into low SES homes may be at an even greater, compounded risk of language impairment (Smith et al., 2007).

The literature has shown that SES can have a protective effect over infants at an increased risk of adverse outcomes, suggesting that high SES may serve as a protective factor for infants, such as those born preterm, who may be more at risk for adverse developmental outcomes (Kurstjens and Wolke, 2001; Stein et al., 2008). Thus, interventions that target infants at risk for language impairment should, in theory, intervene based on deprivation over and above prematurity. Given the overlap between prematurity and low SES, it stands to reason that interventions could begin as early as on the NICU, in an attempt to address the infants at a potentially compounded risk based on both prematurity and deprivation.

Despite evidence suggesting the importance of gestational age, SES and parental communication on infant language outcomes, I was unable to detect any predictive effects in my sample. I will now discuss the strengths and limitations of this study which may have impacted the robustness of the results.

7.4 Limitations and robustness of the methodology

Being well placed within the TEBC study, this thesis benefitted from a large and comprehensive cohort. The TEBC afforded a large longitudinal sample, but ultimately the final study in this thesis has limited power. Due to the timing of this thesis, I was unable to collect a large sample of 24-month-old infants. Additionally, there was a significantly uneven number of preterm vs. term infants included in the

24-month analysis. As participants were recruited into the TEBC at birth, 9-month and 24-month appointment dates were dependent on date of birth. Thus, the necessary cut off point for the completion of this thesis resulted in a significantly smaller available sample at 24 months. Moreover, the onset of COVID-19 further limited the available sample of infants at 24 months.

In addition, infants with congenital anomalies were excluded from the TEBC, thus omitting part of the preterm population. Although excluding participants with multiple comorbidities is the norm within prematurity research, it is nevertheless worth mentioning as a potential limitation. Non-English speakers were also excluded from the investigations in this thesis and thus our results are limited to English language development. Parents were instructed to play with their children as they would normally at home, and any videos where parents used more than 10 instances of a language other than English were excluded from analysis. Thus, most bilingual families were excluded from our study. We did have a few instances of parents with English as a second language who communicated exclusively with their infants in English. These participants were noted in the case of potential outliers, though none of the results were considered outliers by the end of the analysis procedure. We also did not control for siblings or birth order in this study. Again, all instances of twins or siblings were noted, but no outliers emerged.

A significant strength of the TEBC study is the large amount of diverse data being collected. As a result, I was able to compare demographic, questionnaire, and video coded data, which provided a rich sample of variables for assessment. Nevertheless, this study is also limited by missing data. While all language and gesture codes were available, certain other data points, such as SIMD scores, were missing from the final analysis. As a result, although all t-tests and correlations excluded data pairwise, all regressions used listwise exclusions and consequently had smaller sample sizes.

In addition, as parents were aware that they were being videotaped during the parent chid play our data may exhibit a Hawthorne effect, whereby parents behave differently with the knowledge that they are under observation (McCambridge et al., 2014). In an attempt to minimize this, the parent child play portion of data collection at the 9-month appointment took place half way through the appointment. In theory, this allowed parents and infants the opportunity to become accustomed to the laboratory setting and researchers, without risking the infants becoming too fatigued from the other data collection activities.

Language outcome measures used at 24 months, both the MCDI-WS and VABS, were parent report measures, which offers both strengths and potential limitations. Parent report allows for a broader picture of child language as opposed to spontaneous measures of speech in a laboratory setting (Fenson, 2002). By using parent report measures we were able to more accurately capture the diversity of infant language compared to the limited language sample that would have been present had we relied on measures of spontaneous speech. However, while often considered a stable measure of recording infant language (Fenson, 2002), parent report measures are not without their limitations. Parents are at risk of under or over-representing their infant's language development. Moreover, child language described by parental report may actually be measuring differences in parental sensitivity to child language rather than objectively measuring child language output. It could be that parents who are more sensitive to their child's development have a more accurate understanding of their child's language abilities and are more accurately able to report it.

Nevertheless, gesture focused studies are often limited in their sample size and this study is strengthened by its large number of participants and the high volume of coded video (n=100). Video coding is a laborious endeavour, and this thesis benefits from a high volume of detailed coding that resulted in a rich data source and highly informative sample of parent language and gesture. Moreover, the creation of the novel coding scheme is a significant strength of this work. The coding scheme allowed for a high level of objectivity regarding each code. The code categories were designed to be mutually exclusive, as clear as possible, with obvious cut offs and precise definitions that allowed for a high degree of objectivity. By focusing on parental movements, rather than subjective interpretations of parental intentions, I was able to significantly reduce subjectivity from the coding process.

7.5 Methodological contributions

The creation of the novel coding scheme was necessary for the studies undertaken within this thesis. While traditional gesture coding often involves situations of conversation, the reality of having parents interacting with a preverbal infant posed a unique challenge. Parents do not gesture with their preverbal infant in the same way that they would when conversing with a verbal interlocutor. Thus, we were presented with the unique challenge of creating a coding scheme that would capture the particular movements made by parents when interacting with their 9-month-old infant. By expanding on what constitutes typical gesture, we were able to create code categories that allowed for the systematic measurement of parental movement. Similarly to classic gestures, the movements made by parents through interaction with their infant and their environment, functioned to place emphasis on certain elements of speech or to direct infant attention.

The developed coding scheme distinguished between movements that made direct contact with the infant (manipulating infant), the environment (manipulating object), or directed infant attention or placed emphasis on certain elements of speech (pointing). In addition, we were able to accurately capture parent language and subsequently provide measurements of diversity and quantity of language used by parents when interacting with their infants. The coding scheme was designed to have a high level of objectivity, attempting to avoid any subjective assessments of gestures and thus eliminating the need for inferences as to the intention of the parent gesture. The codes were designed to be mutually exclusive, and the inclusion of the other category ensured that all parent movement eligible for coding was measured. Additionally, the coding scheme was designed to be used with ELAN and CLAN, both free public access software, commonly used internationally in language and gesture research.

A significant limitation of the coding procedure is that this thesis did not allow for the capturing of infant language or gesture. Due to time constraints, I was unable to code for any infant specific linguistic events, such as infant gesture, babbling, pre-linguistic verbal behaviour, or turn taking between parents and infants. These measures of infant behaviour and conversational reciprocity would have afforded a potentially clearer picture of any differences between parent behaviours due to prematurity or socioeconomics.

7.6 Theoretical and clinical contributions

It is well established in the literature that children from low SES homes are at an increased risk of delayed language development (Hoff, 2003). It is also well established that preterm infants are at an increased risk for adverse language outcomes (Cattani et al., 2010). Finally, the literature shows that mothers from a low SES are at an increased risk of preterm delivery (Smith et al., 2007). From these lines of inquiry, it is clear that there is a complex but robust relationship between prematurity, SES and language risk. While we don't fully understand the mechanisms through which these relationships operate, it is evident that both preterm infants and children from low SES homes exhibit an increased language risk. From these established relationships, it follows that there is a low SES, preterm group that emerges as being at a potentially increased risk of adverse language development. My thesis adds to this knowledge by showing that SES is an important predictor of parent communication, which may in turn shape the developing infant's language. Future interventions can use the investigations from this thesis to inform possible avenues of intervention and to identify children who belong to both the preterm and the low SES group, who may be at an additional increased risk (Ene et al., 2019).

7.6.1 Avenues for intervention

From the results of this thesis we cannot be sure that parent language input strongly affects later infant language output. However, if true, then this proposed relationship has important implications for avenues of intervention. SES is a complicated and multifaceted factor that cannot be easily shifted, with any possible routes for change far beyond the means of any singular plan for intervention. That said, what can be more easily influenced is how parents are choosing to communicate with their infants. By encouraging parents to provide a rich linguistic environment we could act to mitigate the disparity of language exposure experienced by infants of a lower SES background. Thus, though not directly affecting SES, there is the possibility of interventions encouraging parents to use increased levels and diversity of language and gesture with their young infants, thereby mitigating the SES effects observed in these investigations. Moreover, these interventions could be targeted at the preterm infant population, such as in the NICU, to help mitigate the early paucity of language exposure experienced by preterm infants that was discussed at the beginning of this thesis, and help build early foundational language patterns and habits between infants and parents.

Finally, the results of this thesis shift the narrative of prematurity and language risk to a more deprivation based perspective. Our evidence shows that SES, and not gestational age, affects parental communication, suggesting that SES plays an important role in the language development environment of infants. Moreover, this thesis proposes that the evidence suggesting increased language risk in preterms may in fact be mediated by SES. It may be that the well-known risk of language delay in the preterm population is in fact actually an increased risk of language delay due to the increased levels of deprivation often experienced by this population (Foster-Cohen et al., 2010). Thus, the results presented here argue for more deprivation based interventions. If an increase in parental language and gesture exposure experienced by a high SES group serves as a protective factor against adverse language outcomes, then interventions focused on increasing parental language and gesture may be of particular importance to the low SES population. Moreover, preterm children of a low SES background may be considered at a compounded risk of language delay, and may benefit even more so from interventions aimed at increasing parent language and gesture. The results of this thesis argue for a shift in focus from the potential language effects due to prematurity, to the language effects due to increases in deprivation.

7.7 Future directions

While this thesis has demonstrated an association between parental language and SES, more work is needed to understand the mechanism through which this relationship operates. Future research should include a larger sample size at 24 months, to produce a more robust result. Additionally, the work in this thesis is limited to participants living in Scotland, and further work examining the relationship between SES and language in other English-speaking countries would result in a more comprehensive understanding of the relationship between SES, parental language and gestational age at birth. Moreover, additional work including bilingual families would provide important insight into how a multiple language learning environment affects infant language development in preterms and in high and low SES households.

Future research would also benefit from using multiple measurement time points to ensure a more accurate and generalizable series of results. As language development is a dynamic and multifaceted process, more time points would allow for a more accurate measurement of infant language outcomes and may reveal effects not shown in this thesis. While this work has demonstrated that parental communication is not affected by gestational age at birth, the results only refer to a precise moment of data collection. Given the evidence suggesting a paucity of maternal voice immediately following preterm birth, further work examining the immediate language environment of preterm infants would allow for a more comprehensive understanding of the early language exposure experienced by infants born preterm. Additionally, more data collection points may reveal language differences related to gestational age that were unable to be captured at the measurement time points used in this thesis.

Finally, in terms of methodology, the novel coding scheme developed in this thesis can be expanded and adapted to include infant language output, or to measure parental communication with a verbal interlocutor. The coding scheme could be used to capture parent child play with children of older ages, to see if parental language and gesture is affected in the same way by SES when interacting with a verbal partner. Moreover, the coding scheme could also be adapted and used with a focus on infants, to capture how they interact with the environment, direct adult attention, or communicate non-verbally with their communication partner.

7.8 Conclusion

The results of this thesis suggest an important change in narrative. While much of the prematurity literature suggests a prematurity specific risk for adverse language outcomes, the data presented here suggest that it is in fact deprivation that may be of the utmost importance. I have shown that prematurity does not directly affect parental language, but that high SES is associated with an increase in quantity and quality of parental speech. I have highlighted the importance for examining both the verbal and non-verbal linguistic input of parents, and have emphasised the various ways in which video coding can be used to better understand parental language and its effect on infant development.

While I have not established the predictive effects of prematurity, SES and parental communication on infant language outcomes, I have emphasised that this is an important area for possible interventions. Furthermore, I have highlighted how future research can build on the work presented in this thesis to expand our understanding of the predictive factors of infant language development, and the important relationship between SES, prematurity, and parental language and gesture. The observations of SES based effects on parental language suggests that deprivation, and the increased rate of deprivation amongst the preterm born population, may be a currently undervalued factor to consider when examining the increased risk of language delay in infants born preterm.

The language that children are exposed to has vital consequences for their own communication development, and ensuring that children have access to a rich linguistic environment is of great importance. While we did not reveal any group differences between infant language, we cannot say with absolute certainty that such group differences won't be apparent as the infants in this sample continue to develop. My hope is that the work in this thesis will help guide future interventions for those children more at risk, due to prematurity, SES, or a combination of both, to ensure that all children, regardless of circumstances at birth, have the necessary input they require to communicate and succeed.

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